May, 1912. | Entomological Series. | Vol. IV, No. I.

Memoirs of the Department of Agriculture in India

ERI SILK

BY

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AGRICULTURAL RESEARCH INSTITUTE, PUSA

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THACKER, SPINK & CO., CALCUTTA

W. THACKER & CO., 2, CREED LANE, LONDON

Price Re. 3

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ENTOMOLOGICAL SERIES

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CALCUTTA:
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CONTENTS.

FRONTISPIECE

PLATE 1

Eri Worms.

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I. INTRODUCTION.

Eri silk is a silk grown in Assam for local use, the fibre being spun, woven and worn by those who grow it. It is known as "Endi" and the woven cloth as "Endi" cloth. It is also exported to Europe for forming spun silk, with the waste silk left after reeling mulberry, tasar and other "reeled" silks. The silk differs from other silks in that it cannot be reeled, *i.e.*, a single continuous thread cannot be obtained from one cocoon as is done in mulberry silk; the cocoon actually is not formed of a long continuous thread as in mulberry silk, but is spun by the worm in layers; it differs also from these silk cocoons in that it is so made that the moth can push its way through one end without softening or cutting the fibres, this end not being really closed but being so blocked with loops of silk that nothing can get in, but the moth, pushing from within, can force its way out.

The silk has also this peculiarity that to get it the cocoons need not be steamed to kill the insect within, as must be done with mulberry or tasar silk; the moth may be allowed to mature inside the

cocoon and emerge ; this removes one of the objections to mulberry silk, in that no life need be taken before the silk can be obtained.

Eri silk will probably be extended to other parts of India which have a suitable climate, not for cultivation on a large scale so much as on a small scale without special appliances or buildings ; the fibre can be spun as cotton is, the yarn can be woven quite readily and the silk cloth produced is the most durable cloth known in India, far more so than cotton. It takes dyes well, the ordinary plant-dyes of this country being more suited to silk than to cotton.

It remains to be seen whether it will be profitable to take it up on a large scale for sale in India or Europe ; the sole disadvantage is the immense amount of space required for rearing the worms, and we do not at present advise anyone to take it up on a large scale unless the spinning and weaving can also be taken up with it and finished cloth produced. There is at present a demand for cocoons, but this might be met by its increased production on a small scale and a large production of cocoons to be sold as cocoons might not be profitable at once.

In these pages the methods found best at Pusa for cultivation on a small scale are described ; further information, and eggs or cocoons can be obtained on application to Pusa ; if a large quantity of eggs is required to commence cultivation, it is necessary to give notice, as eggs cannot be kept for more than ten days and are not always being laid.

II. REARING.

1. Instructions.—The following are short instructions for rearing which give a general account of the process. Following this are more detailed notes on rearing and a full account of the rearing at Pusa.

The insect exists in four stages, the egg, worm, chrysalis and moth. The moths lay eggs, which hatch to worms which feed on castor leaves till they are full grown when they spin cocoons and from these cocoons moths come out. The following are instructions for rearing.

Eggs are obtained and kept in any vessel to which air can get : we keep them in a tray. In very dry hot weather, as when the West wind blows, cover the trays with a damp cloth, better still with a wet gunny cloth. In very cold weather, cover the tray similarly and place it thus covered in the sun during the day, always taking care that the covering cloth does not get dry ; at night no covering is necessary. The eggs are white ; when they turn grey, they are going to hatch. They must then be spread out evenly and the smallest leaves of castor spread over them ; as the worms hatch, they crawl on to the leaves and these leaves can be lifted up and placed in the feeding tray. In hot weather, eggs hatch in seven days ; in cold weather, they may stay as long as 24 days.

When the worms hatch, transfer them to feeding trays ; feed on the small leaves of castor twice a day. Very great care must be taken of young worms ; they must not be mixed with older ones ; all that hatch on the same day must be kept together. The leaves must not be chopped up but each should be torn into two or three pieces. In dry weather, the leaf dries and the worms should be given fresh leaves three or four times a day ; the trays may be covered with wet cloth in order to prevent the leaves drying up soon. In very cold weather, keep the young worms in the sun in the same way as eggs, covered with wet cloth. Worms must never be handled more than absolutely necessary, and that very gently ; each day after they have been given fresh leaves, lift them on the leaves to a fresh tray and, when all are moved, clean the tray.

After a few days the worms stop feeding and look sick ; they are now going to moult and must be left alone ; as they finish moulting and become well, they become restless and want food. Some die at this moult. Continue feeding as before, only feeding also once at nightfall and giving bigger leaves ; in a few days they will again moult. Continue as before and after the next moult (third) feed four times daily, once at night. In hot weather, feed oftener if the worms are restless or the leaf dries up. After the fourth moult, the worms are in the last stage and want feeding five or six times a day, once or twice

at night. If the food is not enough, they will become restless and move about. Never feed worms that are moulting. Keep worms of one age or size together and do not mix them with others. The worms should not be kept overcrowded. Leaves must not be dusty or wet ; the leaf given is to be without the leafstalk. There are two kinds of worms, some are black-spotted and others are without black spots. Of both kinds, in the advanced stages, some remain white and others develop a green colour. When the full-grown worms stop feeding and move about, they want to spin. They do this between 9 and 12 o'clock in the morning and one must be ready then to put them away to spin. White worms turn yellow when they are ready to spin ; another way of telling if worms are ready to spin is to hold each in the fingers near the ear and pass the fingers along the fleshy spines ; a worm ready to spin makes a hollow sound, a worm not ready a dull sound. When the worms get ready for spinning, they deposit a large quantity of excrement and then crawl to the edge of the tray ; collect them then, when they are on the edge of the tray and place them in spinning baskets. The baskets must be ventilated, the best are ordinary fruit baskets, loosely woven. Put on the bottom of the basket a layer of crumpled paper, or chips of dry straw or dry leaves ; on this put the worms ; then add more material and put in more worms. When the basket is full, put on the lid and see that there is no empty space below it. Put a weight on the lid or turn the basket over. About 500 worms can be put into a basket $1\frac{1}{2}$ feet in diameter ; do not overcrowd the worms. After five days in hot weather, or eight days in cold weather, pick out all the cocoons from the basket and spread out evenly on trays. The cocoons are white or brown. By always taking eggs from moths from white cocoons, all the cocoons will come white ; so keep the brown cocoons on one side and do not let their moths' eggs be reared. After the cocoons have been spread out from ten days in summer to a much longer period up to forty days or more in winter, moths come out. Let them alone for some hours, then go round with an empty basket [the spinning basket serves the purpose] and put them on the sides, inside. The

PLATE II.

Picking out Cocoons.

PLATE III.

ERI MOTHS.

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females (which have large bodies) and the males (which have small bodies) are to be placed side by side. They will sit on the sides of the basket ; cover the baskets. The next day pick out all the unpairing moths from the basket and leave the pairing couples alone till the day after ; then pick out all the females by separating them from the males if they are still coupling and put them in a separate basket ; the males may be thrown away. The females will lay eggs there ; scrape off the eggs by means of a blunt knife or stick and keep them for hatching ; the best eggs are laid the first night, usually about eighty by each female on the average ; so if these are sufficient, do not rear the later eggs ; but if many eggs are required, keep those laid on the first three nights. The moths do not fly away and want no food. A moth will lay 200 eggs as a rule ; so that if you start with 100 eggs and rear these, you should get 90 moths, of which perhaps forty will lay eggs, laying in all some 8,000 eggs ; these moths will lay some 600,000 eggs. Be careful not to rear more eggs than you can feed.

Use of Cocoons.—After the moths have all come out, pick over the cocoons and get off any straw, etc. Then boil them in water ; use about 2½ gallons of water (a little more than half of a kerosine tin or about 10 litres), half of a seer (1℔) of cocoons and 2 chittacks (4 oz.) of washing soda. It is best to first soak the cocoons in water for 18 hours ; then wash them well in enough water by squeezing them with the hands until all the dirt is removed ; boil the soda in fresh water (2½ gallons) and tie up the cocoons in a cloth and drop this bundle into the boiling water and soda and keep the bundle submerged in the boiling water by placing a brick or any heavy thing. Boil for three-quarters of an hour. Then lift the bundle out and keep the liquid left for dyeing if any dyeing is being done. Wash the whole bundle without untying it in enough water until no longer any dirty water comes out of the cocoons. Now squeeze the water out of the bundle. These cocoons can then be dyed or be spun direct. If the spinning is done with the spindle (taku) or the Continuous Spinning Machine, use wet cocoons. If, however, the country spinning wheel (charka) is used, dry the cocoons thoroughly and spin from the dry cocoons. Dry

cocoons can be carded out and spun like wool; but it is better to spin direct from cocoons. A seer of cocoons gives 10 to 12 chittacks of thread, *i.e.*, $\frac{5}{8}$—$\frac{3}{4}$ of the cocoons form thread.

The following are some general principles :—

(1). Try to have always going, some young worms, old worms and cocoons, *i.e.*, do not have all the worms the same age, or at one time you will have a lot of work, later you will have very little.

(2). The same people who rear should do boiling and spinning so as to have work always.

(3). Try to get fresh eggs every year and exchange eggs.

(4). In the hot weather when the dry winds blow, keep out dust, keep the place cool and moist, and feed often and little ; do not give large quantities of leaf which dries up.

(5). Have the castor as near to the rearing house as possible.

(6). Rear only small broods in April, May, large ones in June, July, August, September, October and on till February.

(7). If there is a choice, rear from the largest and best cocoons.

(8). Cocoons get small in the dry hot weather ; that does not matter ; rear from the best.

(9). Good cocoons weigh 2,500 to the seer after the moth has emerged, small ones 3,500 to 4,000.

(10). Seventy-five seers of leaf feed sufficient worms to yield a seer of cocoons.

The following are the instructions given to the rearers in the silkworm house :—

I. Two principal things :

(1). To feed with the best leaves available.

(2). To keep the worms as clean as possible, free from refuse and excrements. To see that they are no in case overcrowded.

II. To weigh :

(*a*) the leaves supplied ;

(*b*) the leaves thrown out by the worms, *i.e.*, wastage ;

(*c*) the excrements thrown out.

PLATE IV.

THE PUSA REARING-HOUSE.

III. Not to handle the worms too much.

IV. To see that the worms do not drop down on the ground; if they do, they are to be instantly picked up and placed on the feeding baskets.

V. If any die, the dead ones should be at once taken out and put into the fire.

VI. To count how many die every day.

VII. Always to pay attention while cleaning first to those trays in which the worms seem to be most uncleanly or overcrowded.

VIII. Not to let the worms spin in the feeding trays. If any cocoons are spun in the trays, they are to be taken out when seen.

IX. To keep the cocoons clean.

X. To take a turn round the whole house every half hour, keeping the eye watchful to find out:

(1) if any worms have dropped down;
(2) if any have gone down the baskets;
(3) if any have died;
(4) if any are straying about;
(5) if any want to spin;
(6) whether leaves are to be supplied to any tray.

XI. As rats destroy cocoons and worms at night, the cocoons are always to be kept in closed tight baskets into which rats cannot enter. It cannot be helped for the worms, as they are to be fed in open trays.

2. *The Rearing House and Appliances.*—The rearing house at Pusa (Plate IV) is constructed of bamboos and thatching grass, in the usual way, with a row of sissu trunks in the centre as posts since the width of the building is considerable. The construction of the sides allows of ample ventilation. The upper portions of the side walls are so made that they can be lifted up or shut down as desired. There are no special features about the house and a rearing house requires only to be so built as to contain the greatest possible amount of space for trays. The nature of the house and its arrangement vary according to locality and climate; too much ventilation in a cold climate, which lets the temperature fall below

55° F. at night, is bad; so also in dry hot weather; for many places mud walls and a thatch or tile roof are best. Mud-walled thatched houses have this advantage that they are cool in summer and warm in winter. The question depends mainly on local conditions and no general recommendations can be made. It is important to keep the floor of the house as clean and free from dust as possible, especially in view of disease. With an earth floor such as we have, constant wetting is necessary to keep down dust, and this helps to keep the house cool and moist in hot weather. For the same reason if any choice can be made, rearing houses should be as far removed from dusty places or roads as possible.

In the rearing house at Pusa a framework of split bamboo is built up in the middle and at each side, as illustrated (Fig. 1);

Fig. 1.

it is 27 inches high and has a shelf 15 inches below. A double row of trays can be accommodated.

When the rearing of Eri silk worms is taken up as a small subsidiary industry by a cultivator, he need not build any special rearing house. He can use a corner of any available house and in order to accommodate the trays in the smallest possible space, a machan of the kind shown in Fig. 2 can be built. This

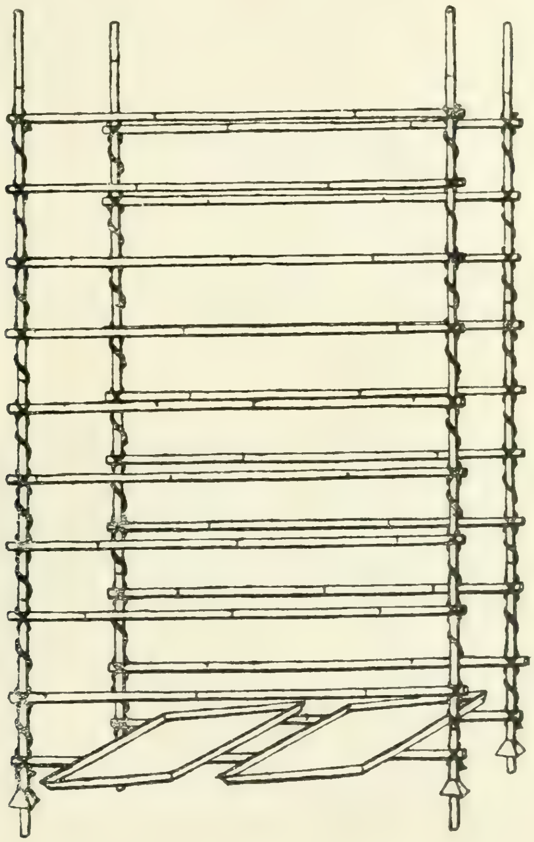


Fig. 2.

machan is formed by fixing two pairs of upright posts in the ground and tying crossbars horizontally. The pairs of parallel crossbars at the same level form shelves. When no rearing is done, the machan can be easily dismantled and kept aside.

Rearing appliances include trays and baskets only. We used in the beginning the small close-mesh trays (Fig. 3) for eggs and young worms. As the worms grew larger, open-mesh trays were used (Fig. 4); these had a raised bottom so that much of the excreta dropped down and they remained more or less clean. Occasionally the tray shown in Fig. 5 was used when the worms were about to spin; it is an ordinary open-mesh tray with an extra space all round which is filled with straw or waste paper or any spinning medium, and as each worm becomes full-grown, it crawls in and spins without requiring separate attention.

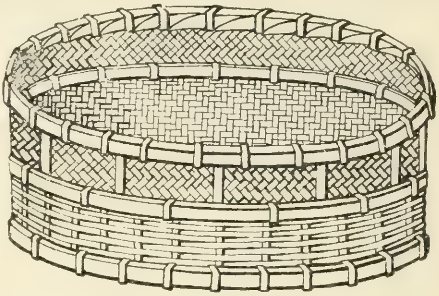


FIG. 3.

FIG. 4.

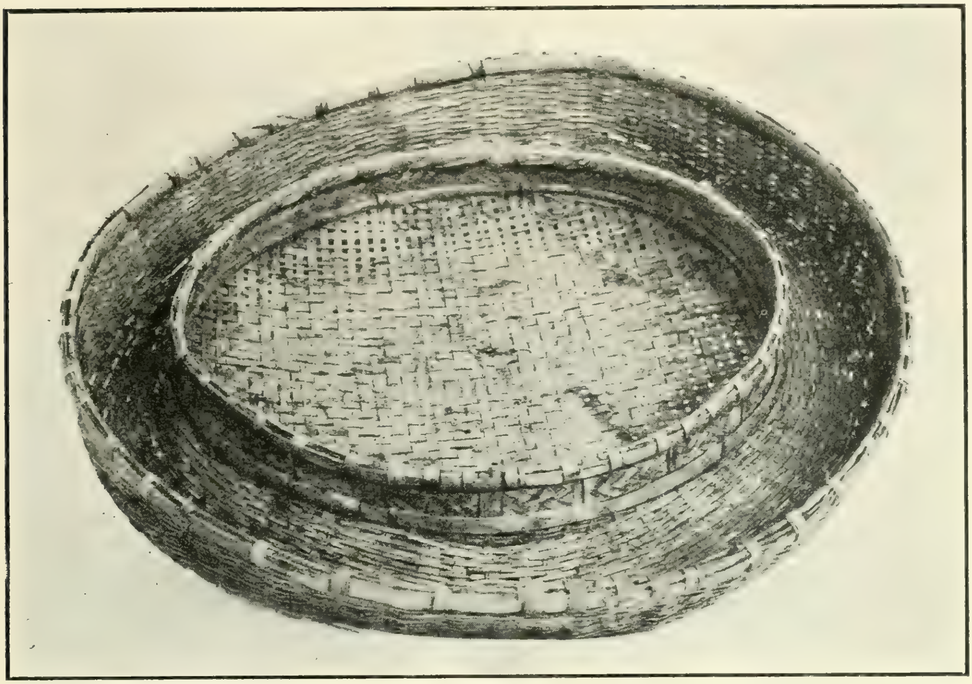


FIG. 5.

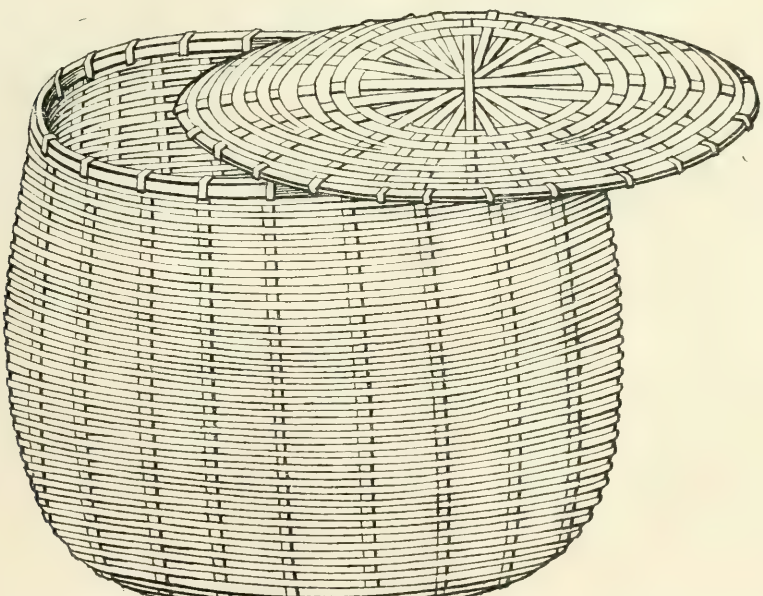


FIG. 6.

The trays with holes are disadvantageous in this way that when they are placed one over another on the shelves, mats must be used between them or the excrements of the worms above drop on the worms below. If a little care is taken in cleaning, the worms in all stages can be as well kept in trays without any holes. Covered baskets (Fig. 6), such as are used for fruit, are required for cocoons and moths. The emergence tray shown in Fig. 7 is the only

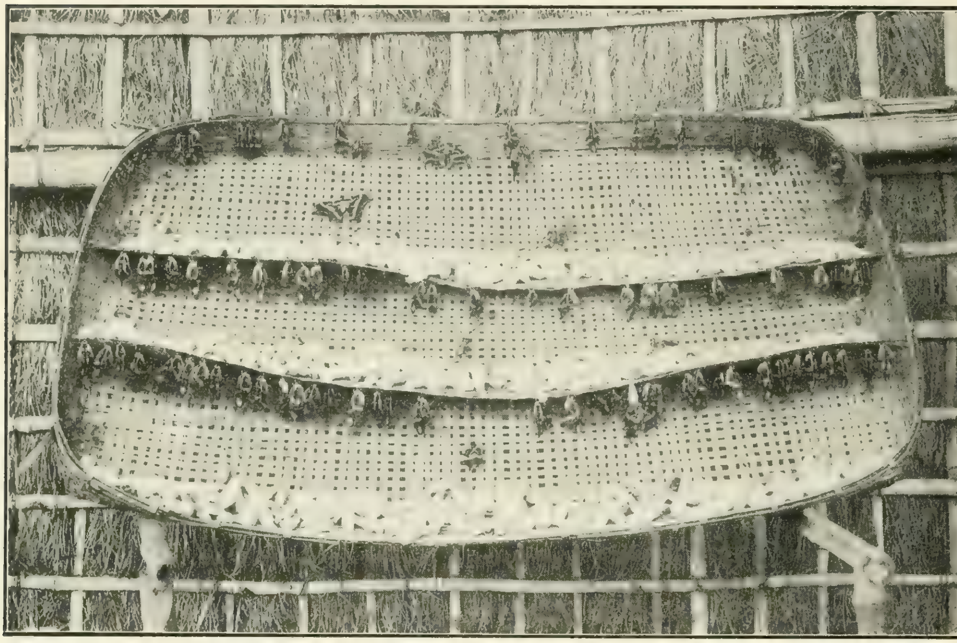


FIG. 7.

new feature; it is placed at an angle and the cocoons spread out; the moths as they emerge crawl up to the lower side of the cross partition, where they hang till the wings expand. They also void their excrement on the tray, not on the cocoons and the pierced cocoons are cleaner.

We now use only trays with completely closed meshes, either square or oblong and of a size which is easy to handle. These are

really small mats with their edges turned up (Fig. 8). These trays can be very conveniently used for making the worms spin cocoons with

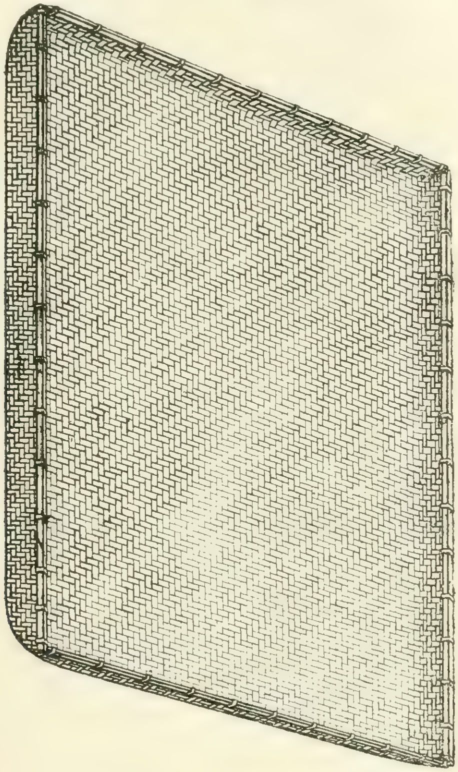


FIG. 8.

the spinning medium, straw, dry leaves, etc., spread on them. For rearing therefore are necessary, a number of these trays which can be used both for feeding the worms and making them spin cocoons, a few small trays (Fig. 3), for eggs and a few covered baskets (Fig. 4), for taking eggs from moths. The eggs can be kept on feeding trays and the small trays can be dispensed with ; but the latter are convenient when eggs are to be covered with wet cloth in the hot season.

The trays can be made of any cheap material available in any locality. We use bamboo. In the United Provinces a weed locally known as *sirki* is very plentiful, and trays, etc., are made of this and sold very cheap. A little modification in the make so as to have the sides not so high as usually made, would fit them admirably for silkworms.

For rearing on a large scale, the use of trays is unnecessary and costly; they are used only for the eggs to hatch and for the young worms. A few of the small round trays may be used and a few larger rectangular trays. For the worms after the first moult, plain pieces of mat are used and the worms can be handled easily, kept well spaced out and readily cleaned and fed. So also for spinning, the enormous mass of baskets required on a large scale and the great amount of material is difficult to maintain; it is best to let the worms spin in a deep layer of dry mango leaves spread out on a machan or floor, mango leaves being the best material yet found on account of the shape of the dry leaf offering convenient cavities for the worms.

Coupling.

I. Experiments to determine the best period of coupling and the number of eggs laid :—

(1). Moth emerged 16th November was kept separate and not fertilised.

She laid eggs as follows :—

	6 eggs on night of	19th November.
	12 ,, ,, ,, ,,	20th ,,
	12 ,, ,, ,, ,,	21st ,,
	27 ,, ,, ,, ,,	22nd ,,
	43 ,, ,, ,, ,,	23rd ,,
	53 ,, ,, ,, ,,	24th ,,
	35 ,, ,, ,, ,,	25th ,,
	45 ,, ,, ,, ,,	26th ,,
	40 ,, ,, ,, ,,	27th ,,
Total	273	

She died on 3rd December.

The eggs did not hatch.

(2). Moth emerged 8 A.M., 14th November.

Coupled 1 hour, between 9 & 10 A.M., 15th November.

She laid eggs as follows :—

	6 eggs on night of	15th November.
	8 ,, ,, ,, ,,	16th ,,
	16 ,, ,, ,, ,,	17th ,,
Carried over	30	

Brought forward 30		
21	eggs on night of	18th November
17	,, ,, ,, ,,	19th ,,
30	,, ,, ,, ,,	20th ,,
33	,, ,, ,, ,,	21st ,,
73	,, ,, ,, ,,	22nd ,,
TOTAL 204		

Only 8 eggs became grey, none hatched.

(3). Moth emerged 8 A.M., 14th November.

Coupled 9—11 A.M., 15th November, *i.e.*, for 2 hours.

She laid eggs as follows :—

8	laid on night of	15th November.	5 turned grey.
9	,, ,, ,, ,,	16th ,,	2 ,, ,,
8	,, ,, ,, ,,	17th ,,	1 ,, ,,
20	,, ,, ,, ,,	18th ,,	3 ,, ,,
48	,, ,, ,, ,,	19th ,,	11 ,, ,,
75	,, ,, ,, ,,	20th ,,	15 ,, ,,
TOTAL 168			

None hatched. She died 21st November.

(4). Moth emerged 8 A.M., 14th November.

Coupled 9—12 A.M., 15th November, *i.e.*, for 3 hours.

She laid eggs as follows :—

3	eggs laid on night of	15th November.
13	,, ,, ,, ,, ,,	16th ,,
29	,, ,, ,, ,, ,,	17th ,,
21	,, ,, ,, ,, ,,	18th ,,
41	,, ,, ,, ,, ,,	19th ,,
17	,, ,, ,, ,, ,,	20th ,,
TOTAL 124		

Of these only 4 turned grey. None hatched. She died 21st November.

(5). Moth emerged 8 A.M., 14th November.

Moth coupled 9 A.M. to 3 P.M. 15th November, *i.e.*, for 6 hours.

Eggs laid as follows :—

No.	Date.	Weight per 100.	Hatched.	Number not hatched.
65	15th Nov.	2·84 grains.	30-11	
38	16th Nov.	2·76 ,,	30-11	
27	17th Nov.	2·64 ,,	23-12	
20	18th Nov.	2·50 ,,	5-12	2
19	19th Nov.	2·40 ,,	6-12	3
11	20th Nov.	2·40 ,,	7-12	1
26	21st Nov.	2·00 ,,	8-12	6
7	22nd Nov.	2·00 ,,	. .	6
213				

Moth died, 29th November.

(6). Moth emerged 8 A.M., 14th November.

Moth coupled 3 P.M. of 15-XI to 7 A.M. of 16-XI.

Eggs laid :—

1	16th November.			
6	17th	,,	6 turned grey.	
14	18th	,,	4 ,,	,,
19	19th	,,	19 ,,	,,
34	20th	,,	34 ,,	,,
29	21st	,,	29 ,,	,,
28	22nd	,,	28 ,,	,,
32	23rd	,,	32 ,,	,,
27	24th	,,	7 ,,	,,
3	25th	,,	none ,,	,,
193				

She died, 29-XI. None hatched.

(7). Moth emerged noon of 13th November.

Moth coupled 6 P.M. of 13-XI to 6 P.M. of 14-XI.

73 eggs laid on night of 14-XI, which weighed 3·4 grains per 100, and hatched 28 and 29-XI.

Was coupling on morning of 15-XI. 9 eggs laid night of 15-XI, which weighed 2·9 grains per 100, and hatched on 29-XI.

Was coupling on morning of 16-XI. 141 eggs laid night of 16-XI, weighing 2·9 grains per 100, hatched on 1-XII.

Was coupling on morning of 17-XI and was separated at 9 A.M., 98 eggs laid night of 17-XI, weighing 2·72 grains per 100, which hatched on 2nd—4th December.

21 eggs laid night of 18-XI, weighing 2·5 grains per 100, hatched on 5-XII.

19 eggs laid night of 19-XI, weighing 2·4 grains per 100, hatched 7-XII.

9 eggs laid night of 20-XI, weighing 2·3 grains per 100, hatched on 7-XII.

7 eggs laid night of 21-XI, hatched on 9-XII.

One egg laid, 22-XI, hatched on 9-XII.

Total, 378 eggs. Moth died, 23-XI.

In the following three cases, copulation ran its full course, the pairs being isolated but not separated :

(8). Emerged, 25th March.
Coupled night of 25th March to morning of 27th March.
235 eggs laid night of 27th March.
Were coupling on morning of 28th March.
Ceased coupling and laid 101 eggs, night of 28th March.
49 eggs laid night of 29th March, and the male died.
20 eggs laid night of 30th March.
10 eggs laid night of 31st March.
Female died, 1st April.
415 eggs laid, which hatched.

(9). Emerged, 25th March.
Commenced coupling night of 25th March.
27 eggs laid night of 26th March.
The couple separated on 27th March.
15 eggs laid during day of 27th March.
14 eggs laid during night of 27th March.
Coupled again, 28th March.
17 eggs laid night of 28th March.
Ceased to pair, morning of 30th March.
Male died, 30th March.
5 eggs laid night of 31st March.
Female died, 1st April.
188 eggs laid, which hatched.

(10). Emerged, 25th March.
Coupled, 25th March.
25 eggs laid night of 27th March.
Were still found coupling morning of 28th March.
Ceased to pair and laid 247 eggs, night of 28th March.
59 eggs laid night of 29th March.
Male died night of 29th March.
17 eggs laid night of 30th March.
6 eggs laid night of 31st March.
Female died, 1st April.
Total, 354 eggs laid.

In the above cases, the number of eggs varies from 124 to 415; the coupling should occupy 24 hours to be effective and the best eggs are laid on the first night, after separation; eggs are laid in spite of continued coupling. Unless separated, coupling continues for about 72 hours, and males in some cases died coupling. Pairs isolated and separated after 30 hours coupling, coupled again and the eggs laid hatched. The best practice is to allow coupling for 24 hours, and, unless a large increase is required, to keep for hatching only the eggs of the first night's laying. On 6th November, 250 female moths that emerged were allowed to couple and were separated on 8th November; they laid 21,800 eggs that night, giving an average of a little over 80 eggs each for the first night's laying, which the above tables show to be heavy eggs.

4. The Eggs.

Moths lay eggs wherever they are sitting, in a cluster which may contain as much as 100 or more; each egg is coated with gum which dries, fastening the eggs firmly together and as the moth moves little, the eggs are often built up as a little curved wall behind her, projecting out at right angles to the surface she is resting on. The eggs are white, but the gum gives them a yellow look; they are oval in outline, and with a very tough smooth shell. In moist warm weather they hatch in seven to nine days; exposed to the dry heat of the west winds in March, they required some days more, eleven to twelve days in all. Moisture is a necessity for prompt

hatching, possibly because of the amount absorbed in the development of the embryo before it can emerge.

Eggs should never be kept in air-tight vessels or boxes. In Assam, eggs are kept tied in a piece of cloth and hanging from eaves, etc. Sometimes water is sprinkled on the eggs ; dipping in water does them no harm—$\frac{1}{2}$% solution of blue-stone (Copper Sulphate) is salutary. We have even used 1% solution of blue-stone without any injury. Eggs are put in a piece of cloth which is dipped in the solution until the eggs are thoroughly wet. The water is then jerked out as much as possible and the eggs spread to dry in the shade. In summer, the rains and in early winter, the eggs do not require any special moist surroundings. In very cold weather they keep well and hatch uniformly if kept in a moist and at the same time warm condition. This is brought about by covering the tray in which they are kept with a wet cloth and placing the tray thus covered in the sun, always taking care that the cloth does not get dry. When the dry west winds blow, they are to be put in slightly moist surroundings. They keep well if they are kept covered with a moist cloth. If the eggs are kept in a castor leaf or any other big fresh leaf and the leaf itself tied in a piece of cloth and kept in a cool place, the eggs keep well ; the leaf has to be changed when dry. Moist leaf is favourable to the worm in all its stages.

The best method of taking eggs from the moths is in covered baskets (Fig. 6). For this purpose the baskets in which the worms are made to spin cocoons may be very conveniently used. As the moths emerge they are picked out and placed inside the basket ; they are made to hang on the sides and never placed on the bottom. Female moths will hardly stir from the place where they are put. Males flutter about at nightfall. A male and a female are put together almost touching each other or the male may be made to hang on the body of the female. The moths are to be put in this way before it is evening. Next morning most of the pairs will be found to be coupling. The single unpairing moths are now removed from the basket. Twenty-four hours copulation is enough for the fertilisation of the eggs. Practically we have found the following method to

be very good :—Moths which couple to-night are allowed to mate for to-night, to-morrow day and night, the day after to-morrow till about 2 or 3 P.M., when the males are forcibly separated and thrown away, the females are kept in a clean basket and lay eggs at night ; on this night on an average each female will lay about 80 eggs. If a large number of females is available, it is better to take only the eggs of the first night and then reject the females. At any rate, if more females are not available, eggs of only the first three nights should be taken and the females rejected. (The eggs of subsequent nights become gradually smaller and weigh less.) Some couples will be found to have separated after 24 hours' copulation and the females to have laid eggs. (Paired this evening and separated and laid eggs to-morrow night.) These eggs should be taken as they are quite healthy and fertile. Other methods of taking eggs, *e.g.*, by tying the moths to reeds, etc., are unsatisfactory.

Eggs turn grey before hatching. Eggs laid on the same night should be kept together and separately from those of other days. Eggs of the same day will turn grey at the same time ; if among them any eggs are found not to have turned grey they should be picked out and rejected, usually they fail to hatch, and if they hatch at all, the worms lag behind and usually die.

Eggs laid on the same day hatch almost at the same time. If any eggs of the same lot fail to hatch within two days of first hatching of the batch, they should be rejected as not quite healthy.

Eggs lose in weight as they approach maturity :

100 eggs laid 17 September (night).

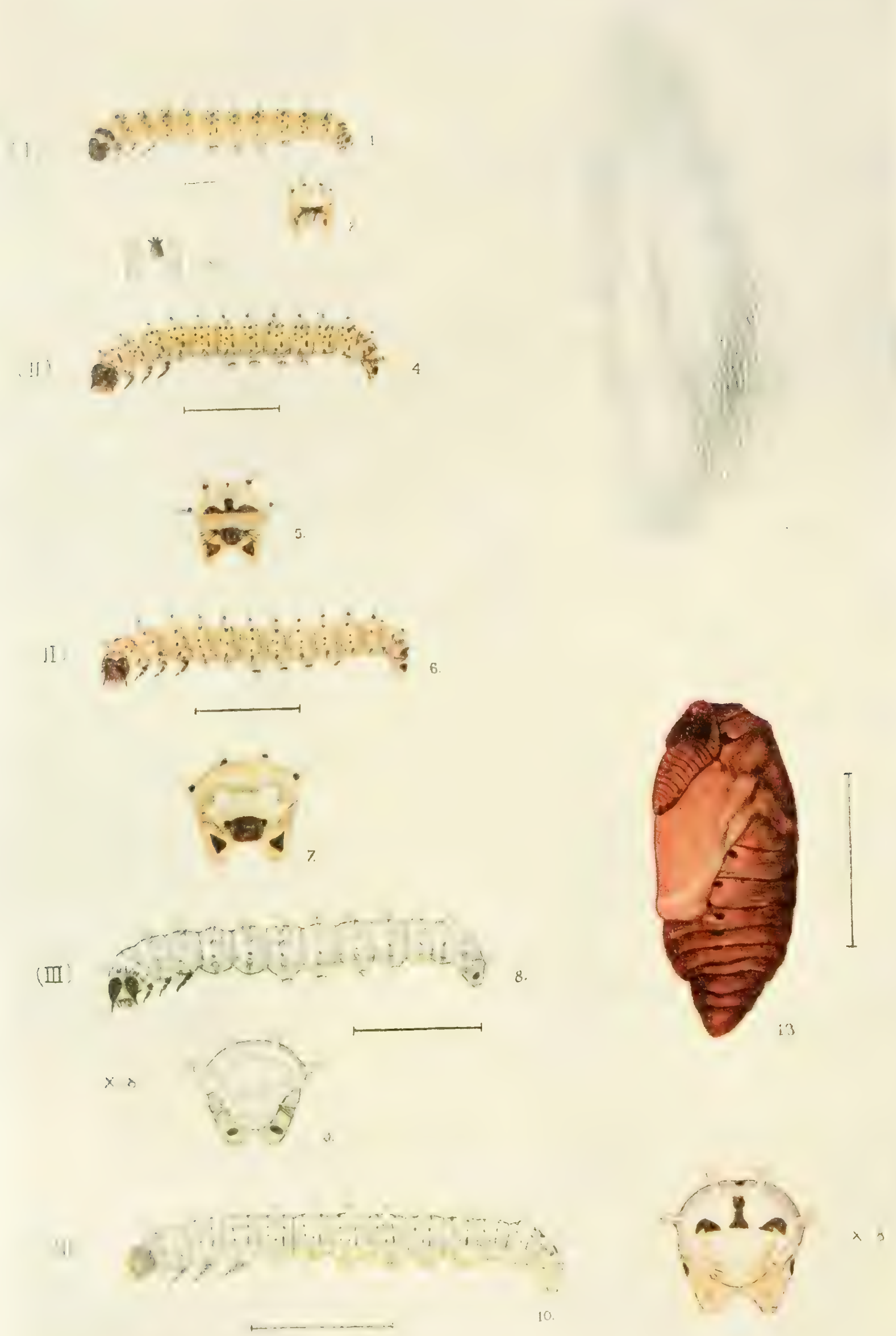
Weighed on	18-9	2·65	grains.	
,, ,,	21-9	2·56	,,	
,, ,,	23-9	2·43	,,	
,, ,,	25-9	2·35	,,	(Hatched).

98 newly hatched worms weighed 1·80 grains.

5. Description of the Stages of the Worm.

First Stage.—Length about 5 m.m. The body is cylindrical with distinct segments. The head is black, shiny. There is a black prothoracic shield. The general colour of body, when just hatched,

PLATE V.



Young Eri Worms.

Engraved and Printed by The Calcutta Phototype Co.

EXPLANATION OF PLATE V.

Fig.	1.	Worm in first stage.						
,,	2.	,,	,,	,,		anal view.		
,,	3.	,,	,,	,,		tubercle more highly magnified.		
,,	4.	,,	,, second stage,			black-spotted.		
,,	5.	,,	,,	,,	,,	anal view.		
,,	6.	,,	,,	,,	,,	unspotted form.		
,,	7.	,,	,,	,,	,,	,,	,,	anal view.
,,	8.	,,	,, third stage,			,,	,,	
,,	9.	,,	,,	,,	,,	,,	,,	anal view.
,,	10.	,,	,,	,,	,,	spotted form.		
,,	11.	,,	,,	,,	,,	,,	,,	anal view.
,,	12.	Cocoon.						
,,	13.	Pupa removed from cocoon.						

is pale yellow ; in the course of a day a slightly greenish tinge is developed ; but the colour becomes deeper yellow later on.

From mesothorax to 7th abdominal segment, each segment has got five pairs of black spots, all the spots making up 5 rows (of black spots on the back), *viz.*, 1 median, 2 submedian and 2 lateral or spiracular ; with the spiracle where present a segment shows 3 black spots along this row, the posterior of them being oval and elongated. On the prothorax, the region of the median and submedian spots is occupied by the shield ; also the spiracular spots are not distinct. In the posterior segments the spots are not so distinct.

From prothorax to the 7th abdominal segment, each segment has got six small fleshy tubercular spines, mounted with a varying number of hairs (hairs varying from 2 in some to 9 in others). These fleshy spines are arranged in longitudinal rows which alternate with those of the black spots. On each of the three thoracic segments there is a fourth smaller spine on each side just above the leg. On the prothorax the four upper spines are on the shield. On the 8th abdominal segment there are only five such fleshy spines, one in a line with the middorsal row of black spots and two on each side. On the 9th abdominal segment, there are only four such spines alternating in position with those on the preceding segment. When hatched from the egg, these spines are yellow with the hairs whitish ; but in the course of about 12 hours, the spines as well as the hairs on them become black, when the larva looks much black-spotted.

The anal shield is black and prominent and has got two very small similar spines on it. The prolegs are all developed ; the four pairs of abdominal ones are yellow with the tips blackish ; the bases of the anal prolegs are black on the outside.

In later stages these fleshy spines become very big and prominent, while the hairs on them become less in number and very short.

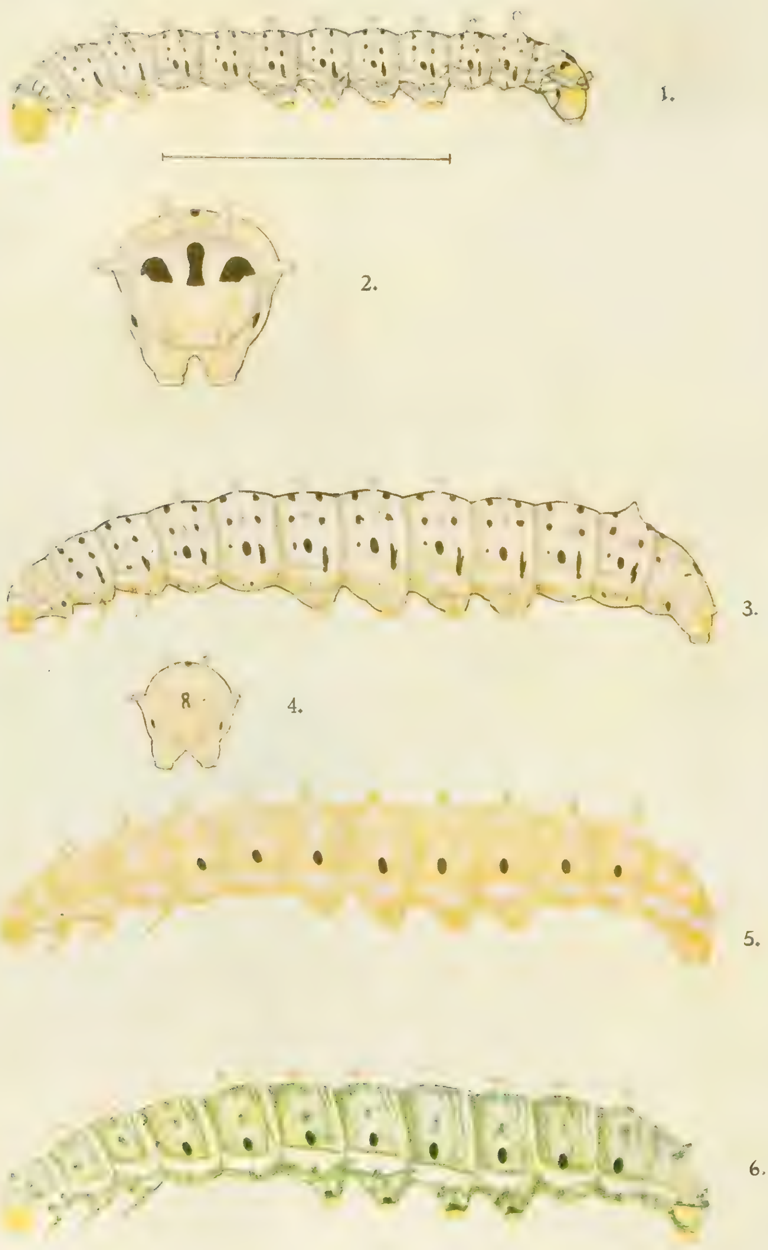
From the second stage onwards the black spots are retained in some larvæ ; while in others they altogether disappear in the second stage ; in a few, a few of the black spots may be present very faintly till the third stage and then disappear. The two kinds of larvæ are very distinct in the advanced stages, *viz.*, black-spotted

ones and unspotted ones. The presence or absence of black spots is not indicative of sex; both kinds may turn into either male or female moths. The offspring of either has been seen to be spotted and unspotted mixed. If only unspotted ones are bred, the majority tend to be unspotted. On the other hand, if spotted ones are bred, the majority tend to be spotted. From the very beginning the majority of the worms in all the broods were unspotted, the spotted ones being not more than ten per cent.; in some cases they were much less. Some spotted worms were made to spin separately; from these both females and males emerged; of the worms from the eggs of these moths more than 50 per cent. (but not all) were black-spotted. In other baskets of worms from eggs of moths of spotted and unspotted worms kept mixed together as ordinarily done, the percentage of black-spotted worms was 2 to 10. In this way it is possible to eliminate either spotted or unspotted worms wholly. The presence or absence of the black spots in the worms in the later stages seems to be an accident as in the early stage all the worms possess these spots.

Second stage.—Length about 12—15 m.m. Head black, shiny. The prothoracic shield is now reduced to two black markings at the posterior part of the prothorax, one being on each side of the median line and both elongated transversely. The four upper fleshy spines on the prothorax are placed on its anterior part and thus apart from the reduced shield. The general colour is yellow, but not so deep as in the first stage. All the fleshy spines on the body have become yellow, but their tips remain black. The black anal shield has got a pair of distinct spines mounted with hairs.

In some the black spots have disappeared; in a few a faint row of median faint spots is present. In the others which have retained the black spots, the spots on the posterior segments have become very distinct, the median spine on the eighth abdominal segment has got one spot anteriorly and 2 spots posteriorly to itself; also on the posterior part of the 9th abdominal segment there have been developed three big black patches alternating in position with the spines on the segment and joined to one another. (These patches are not present on the unspotted worms.)

PLATE VI.



ERI WORMS IN LATER STAGES.

EXPLANATION OF PLATE VI.

Fig. 1.	Worm in fourth stage,	spotted form.					
,, 2.	,,	,,	,,	,,	,,	,,	anal view.
,, 3.	,,	,, fifth (last)	,,	,,	,,		
,, 4.	,,	,,	,,	,,	,,	,,	anal view.
,, 5.	,,	,,	,,	,,	unspotted white form.		
,, 6.	,,	,,	,,	,,	,,	green form.	

Just after the first moult, the head is pale yellowish-white, the body and legs are pale yellow ; in the case of unspotted worms only the spiracles are black ; over and above these, black spots are present in the case of the spotted ones with the black patches on the posterior part of the 9th abdominal segment.

Third stage.—Just after the second moult, the head is yellowish white as also the legs and spines ; the general colour is pale yellow. As after every moult, the black spots are present in the case of the spotted worms. In the course of about 24 hours the colour changes to white and the head becomes black.

In this stage the worms are about 18—21 m.m. long. The head is black. The cervical shield is now further reduced to two faint black markings on the posterior part of the prothorax. The thoracic legs are black as also the small spines just above the thoracic legs ; in some the tips of the lateral spines are black. The spines are thick and knoblike at the top. The anal shield is no longer black but slightly greenish white. The black patches on the posterior part of the 9th abdominal segment (in the case of the spotted worms) are now detached into three distinct patches, the middle one being somewhat of the shape of a dumb-bell.

Fourth stage.—The length is about 40 m.m. The head is very slightly greenish yellow or yellow ; there is a somewhat big black patch near the posterior margin of each lobe ; a blackish patch is present on each cheek containing the ocelli. There is no trace of the prothoracic shield. Thoracic legs are yellow. The colour is white and covered with a white powdery substance or bloom.

Fifth stage.—In this stage the larvæ eat enormously and so grow very quickly. The well-fed full-grown larvæ are about 95 to 100 m.m. long. The abdominal part is about 15 m.m. thick. The general shape is cylindrical and tapers prominently forward ; the thoracic segments with the head may be kept contracted, so the larva may not always look so tapering. The head is yellow with the blackish patch on each cheek containing the ocelli. Of the three black patches on the posterior part of the 9th abdominal segment of the black-spotted worms, the two on the two sides have almost disappeared

or linger as faint black markings, the dumb-bell-shaped middle one is also reduced and makes a figure of 8 (in some the lower circle is about half cut like 8).

The general colour is white. Some become beautifully green. Those which remain white turn yellow before spinning. In those which have got an excess of the white powdery substance, the yellow colour is not so prominent. The green worms develop beautiful pink spots on the tips of the fleshy spines on the body.

The worms in the different stages can be easily distinguished by the following characteristics :—

First stage. Black head.
Undivided big prothoracic shield.
Yellow body.

Second stage. Black head.
Divided prothoracic shield.
Yellow body.

Third stage. Black head.
White body.

Fourth stage. Yellow head with the black patches on the posterior margin of each side.
(Also in the case of spotted worms the detached dumb-bell-shaped black spot on the posterior part of the 9th abdominal segment.)

Fifth stage. Yellow head without the black patches on the posterior margin of the lobes.
Later on in the stage the big body tapering anteriorly.
(In the case of the spotted worms 8- or Ω- shaped black markings on the posterior part of the 9th abdominal segment.)

6. Life of the Worm.

Resinous Secretion.—The worms secrete a white resinous substance which covers the entire surface of the body in the form of a white powder such as is found covering the stems and leaves of many

varieties of castor. Worms which are fed with great care show an excess of this substance. Again, worms which are allowed to feed at will on living plants secrete a still larger quantity. Therefore, the secretion of this substance is indicative of health and vigour in the worm.

Process of Moulting.—The larva ceases to eat for some time and rests almost motionless for 1 to 3 days according to temperature. At this time it does not like any disturbance. During the period of rest the head gets somewhat detached, showing a sort of a neck behind. The whole period of the rest seems to be spent in extricating the head from the head-moult and then the skin soon glides off behind. The head-moult remains attached to the skin at the throat and is cast off with the skin. The cast skins are never eaten.

Life-cycles.—The following table gives the dates and durations of broods at different seasons of the year; they vary from 37 to 85 days normally, but with the spell of cold which comes once usually in each cold weather, the duration of one brood may go up to 100 days and over.

	Eggs laid.	Eggs hatched.	Worms spun.	Moths out.	Periods.	Total.
1	11-I-1908	4-II	10-III	31-III	24-35-21	80
2	20-I-1908	13-II	17-III	4-IV	24-33-19	76
3	2-III-1908	15-III	7-IV	24-IV	13-23-17	53
4	31-III-1907	8-IV	26-IV	14-V	8-18-18	44
5	9-V-1907	17-V	5-VI	22-VI	8-19-17	44
6	24-VI-1907	1-VII	17-VII	2-VIII	7-16-16	39
7	29-VI-1907	6-VII	22-VII	6-VIII	7-16-15	38
8	1-VII-1907	9-VII	27-VII	14-VIII	8-18-17	43
9	4-VIII-1907	19-VIII	26-VIII	10-IX	6-16-15	37
10	19-VIII-1907	26-VIII	10-IX	26-IX	7-15-16	38
11	22-IX-1907	29-IX	15-X	30-X	7-16-15	38
12	26-IX-1907	3-X	26-X	16-XI	7-23-21	51
13	9-XI-1907	20-XI	8-I	28-II	11-49-51	111
14	24-X-1907	2-XI	27-XI	24-I	8-25-54	87
15	3-VIII-1908	10-VIII	26-VIII	10-IX	7-16-15	38
16	7-VIII-1908	14-VIII	30-VIII	14-IX	7-16-15	38
17	8-VIII-1908	15-VIII	1-IX	16-IX	7-17-15	39
18	13-VIII-1908	21-VIII	4-IX	21-IX	8-14-17	39
19	13-IX-1908	21-IX	6-X	25-X	8-15-19	42
20	27-X-1908	6-XI	{ 12-XII 23-XII	16-I 4-II	10-36-35 10-47-43	81 100
21	14-XI-1908	26-XI	17-I	24-II	12-52-38	102

	Eggs laid.	Eggs hatched.	Worms spun.	Moths out.	Periods.	Total.
22	20-I-1909	9-II	19-III	8-IV	20-38-20	78
23	1-III-1909	12-III	12-IV	28-IV	11-31-16	58
24	3-V-1909	10-V	28-V	12-VI	7-18-15	40
25	14-VI-1909	22 VI	10-VII	25-VII	8-18-15	38
26	27-VII-1909	2-VIII	17-VIII	2-IX	7-17-15	39
27	19-VII-1909	25-VII	10-VIII	25-VIII	6-16-15	37
28	23-VII-1909	29-VII	13-VIII	28-VIII	6-15-16	37
29	5-IX-1910	12-IX	30-IX	19-X	7-18-20	45
30	21-X-1910	1-XI	27-XI	19-I	10-26-53	89

When the eggs turn grey, it is an indication that they are going to hatch within a day or two. At this time they should be fairly spread, so that they are not heaped and one layer of tender leaves of castor spread on them. Each leaf may be torn into 2 or 3 pieces, so that the leaves may almost touch the eggs on which they are placed. Soon after hatching, the worms will crawl up to the underside of the leaves. The leaves are now transferred to a separate tray and turned up so that the worms are above. Fresh leaves are placed on the eggs for other worms to crawl up which can be similarly transferred. The transferred worms are now fed with pieces of fresh tender leaves spread on them. It is unwise to chop the leaves into small pieces, as in that case they dry soon, specially in dry seasons. It is better to take entire leaves in the hand and supply by tearing them into small pieces. When the season is not dry, it is enough if leaves are supplied twice daily to the young worms. In dry seasons care is to be taken to see how soon the leaves are drying and fresh food is to be supplied accordingly, so that the worms may not starve, as they never eat dry leaves. Much greater care has to be bestowed on the worms when they are young than when they are grown. Cleaning of the baskets is done by transferring the worms to a separate tray. When the worms are grown, this can be done easily by placing fresh leaves on the worms which will soon crawl up to the leaves and can be transferred with the leaves. In this way all the worms in a tray can be transferred without handling them roughly. When young, they do not come up to the fresh leaves so soon and cling to the old leaves; these old

leaves are therefore to be transferred carefully with the worm which can then be fed.

If the season is not unfavourable and the leaves do not get dry, generally the number of times the worms are to be fed are the following :—First stages—twice.

Second and third stage—three times (once at night).

Fourth stage—four times (once at night).

Fifth stage—five times (or if possible six times) (once at night or if possible twice at night).

These, however, are not hard and fast rules. The number of times the food has to be supplied will depend much on the quantity supplied each time. When the worms are in the process of moulting, they do not require any food at all, and it is better to leave them quite undisturbed. Food need not be supplied to the worms just after they have emerged from a moult. It is better to leave them without any food for about six hours till they are well out of the sickness. They will themselves signify their hunger by crawling about in search of food.

Worms of different ages should never be kept together; some go into moult while others feed and are active ; those in moult therefore are not left at ease. Besides, as the worms grow, their activity increases ; the bigger ones therefore cause a great deal of inconvenience to the younger ones. This is very harmful especially in the later stages ; when young, the worms are usually in the habit of feeding from the underside of the leaves supplied ; the big worms are more active and show a tendency to get upon the leaves and choke the young ones which may be kept with them ; in such cases it has been seen that the mortality among the younger ones is very high. Of the worms which hatch on the same day, some grow more quickly than the others and it is better to separate them if possible.

In rearing the worms the less crowded and the more clean they are kept, the better. Young worms require tender leaves ; older leaves are to be supplied as they grow old. The leaves should not be covered with dust and as far as possible should not be wet.

In March, April, May, when west winds blow and cover all leaves in the field with dust, we have to wash the leaves before supplying them to the worms. Usually high temperatures prevail about this time and it does not matter if the leaves supplied are not completely and perfectly dry. In the wet season the leaves should be as far as possible not wet. But if the choice lies between only partially wet leaves and leaves which have dried up and lost much of the natural moisture, the former should be preferred.

When full-grown and about to spin cocoons, the worms which are white turn yellow ; the green ones remain green. It is easy to determine whether any worm is ready for spinning ; hold the worm with your finger near your ear and pass the fingers lightly over the fleshy spines ; if the worm is ready for spinning, a hollow sound will be clearly perceptible ; if not, the sound will be dull and solid. In the worms which turn yellow, the yellow colour is a sufficient indication that they are ready for spinning. With the green ones the sound has to be tested. Expert hands can detect a softer feel and a lighter weight in those ready for spinning, but this distinction is very fine. It would be very difficult if the sound test had to be applied to every individual worm, especially when a large number has to be picked for spinning. There is a definite time every day when the worms seek to spin ; this is between 9 and 12 in the morning ; the largest number come up at about 10-30 or 11 A.M. Some worms spin in the feeding baskets at night ; but their number is small and they are mostly those which ripen late, and are left in the baskets.

When the worms get ready for spinning, they cease feeding and pass a large quantity of excrement a part of which is semi-solid and the rest yellow-coloured liquid ; at this time they sit with the thoracic segments contracted and raised upward with the head ; and they present a sickly appearance. After a while, they become active and roam about in search of a place for spinning and come up to the edge of the tray. The best time to pick up the worms for spinning is when they have thus come up to the edge of the tray. If they are picked before this, they may soil the spin-

PLATE VII.

Putting Worms to spin.

ning materials by their liquid excreta. Besides, when spinning has commenced in a brood, almost all the worms which between 9 A.M. to 12 noon thus leave their food and come up to the edges of the baskets and walk about, can be taken to be such as want to spin ; among them the number of unripe worms will be very small - less than 1 per cent. The ripe worms require a hidden corner to form cocoons or any material in which they can hide themselves and find a space for the cocoon, *e.g.*, crumpled paper, pine shavings, dry straw, dry leaves, etc. It is best to supply a material which can afford tolerably big interspaces. A layer of this material is placed at the bottom of the basket and a number of worms dropped in ; then another layer of the material with more worms is put in ; in this way the whole basket is filled up and covered. About 500 worms can be very conveniently made to spin in a basket about $1\frac{1}{2}$ ft. in diameter and about $1\frac{1}{4}$ to $1\frac{1}{2}$ ft. in depth. The worms have got a tendency to come upwards, and care should always be taken to see that no empty space is left below the lid ; the basket should be fully filled with the material ; otherwise many worms will collect in this empty space and cover the whole under-surface of the lid with silk without using it in the cocoons ; a sort of a netted cloth is then produced and also many double cocoons are formed. After filling the basket, a weight has to be put on the lid so that no worms may get out, or the basket may be turned upside down.

Something has already been said about how the worms can be made to spin. If baskets are used, they should be of the kind of those used for packing fresh fruits (litchi baskets), so that air may pass through all the sides; also the best spinning medium is that which affords interspaces all through. In the process of spinning, the worms evolve heat, which must be let out, or it chokes and kills the worms and causes them to rot within a few days. Also the worms spin well, pupate successfully and the pupæ keep well, if ventilation can be kept up through the interspaces of the spinning medium and the sides of the basket, and if free breathing is not interfered with. Some worms were put in a packing case for

spinning and its lid was removed, the mouth being kept covered with a cloth : about three-fourths of the worms died without spinning ; of the rest, those only were good which were at the top. If the spinning basket is a very big one, although its sides may allow passage of air, care should be taken that the worms in the interior are not overpressed and that proper inter-spaces are left in the interior, otherwise the worms there may not spin properly and may die for want of proper breathing. The worms finish spinning in about three days and rest inside the cocoons before turning into pupæ for about one to three days according to temperature. The cocoons can be picked out from the spinning medium after five days in summer and eight days in winter. The baskets can then be used for a fresh lot of worms.

Usually two kinds of cocoons are prepared by the worms, *viz.*, white and red-brown. The colour of the worms, or the presence or absence of spots in them, has nothing to do with the colour of the cocoon. The green as well as the white worms or the spotted as well as the unspotted worms may form either white or red-brown cocoons. It has been observed that worms reared from eggs of moths from white cocoons may form both white and red cocoons, also both red and white cocoons are formed by worms from eggs of moths from red cocoons If, however, only the moths from white cocoons are bred, the red cocoons will gradually disappear and *vice versâ*. In this way, either the white or the red-brown cocoons can be wholly eliminated. Complete elimination can be effected so soon as in the third or fourth generation. It has been suggested that worms spinning in darkness form white cocoons. But it has been definitely proved by making the worms spin in glass dishes in the glare of the sun and also in darkness, that the presence or absence of light is not at all a determining factor in the colour of cocoons. The colour of the red-brown cocoons is not permanent ; it disappears when the cocoons are boiled with ashes or soda, but the yarn from them is not so white as that from the white cocoons. Rarely pink cocoons are formed and also cocoons with a slightly greenish tinge ; but when the moths from these

PLATE VIII.

1.

2.

8.

3.

5.

6.

7.

4.

Eggs and Cocoons of Eri Moths.

Engraved and Printed by The Calcutta Phototype Co.

were bred, the cocoons formed were almost all white. In one case at least it was seen that the pink cocoon was formed by an unhealthy worm. The colour of the food also has nothing to do with the colour of the cocoons ; some worms were fed specially on only red castor leaves but they formed white cocoons.

The rearing at Pusa commenced with seven pairs of moths from cocoons obtained in Kamrup, Assam. The cocoons reared from these in all the generations were all white. Later on, on two occasions we imported eggs and seed cocoons from Gauhati and other places. On both occasions there was a sprinkling of red-brown cocoons. As we did not breed from these red cocoons, they disappeared soon and we obtained only white cocoons. Recently some experiments have been undertaken in crossing Eri silk moths, *Attacus ricini*, Boisd., with *Attacus cynthia*, Drury, which is considered by some as the wild original form of *Attacus ricini*. (The results of this experiment will be published in a future publication.)

The crosses have produced both white and red-brown cocoons. In Assam the rearers generally get both brown and white cocoons. This may probably be due to the fact that they often expose the female moths in such a way that they have a chance of being fertilised by *A. cynthia* which is said to occur wild in some parts of Assam.

There are other methods of allowing the worms to form cocoons which are sometimes as efficacious as the above. One is the use of the *Chandraki* or Spinning Frame of Bengal (Fig. 9) used in mulberry silk. We have tried it, and in damp weather it is successful but takes up much space. In dry hot weather it is unsuitable. Another method is to suspend cloth over horizontal bamboos, so that long folds hang down and to let the worms crawl into the folds to spin. Very clean cocoons can be got in this way and they are readily detached from the cloth ; also very little silk

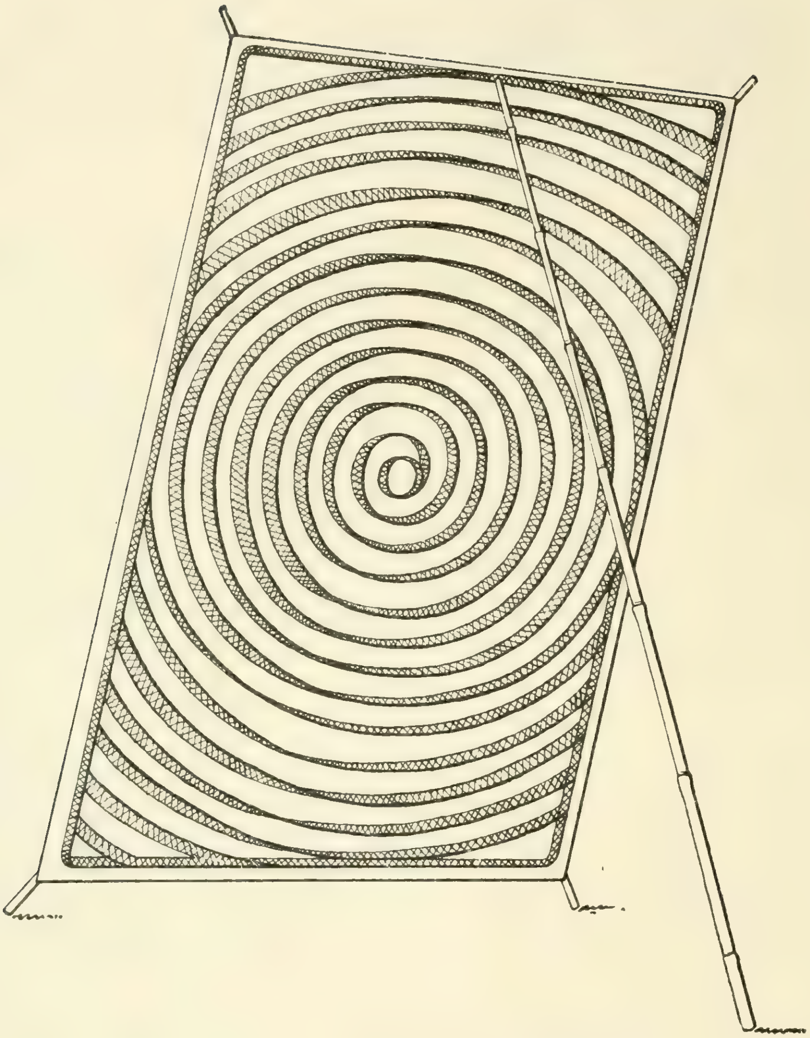


FIG. 9.

is wasted in the cradle or cocoon-foundation. The method requires less space, saves packing material and baskets and is useful when rearing is being done on any large scale.

The following tables give the weights in grains of food, larva, etc., for three individual worms: the first figure is the weight of

food given ; the second is the weight of the same amount of food kept for the same time, as a guide to the loss from evaporation ; the third is the weight of the larva ; the fourth is the food left ; the fifth is the excrement. Were there no evaporation, etc., then the increase of the weight of the larva should equal the difference between the weight of food after evaporation (column 3), and the combined weight of food left (column 5) and the excrement (column 6). In all cases the eggs were laid on 30-III, hatched 7-IV, the weight of 100 eggs being 3 grains and of 100 larvæ about 2 grains.

(A.)

Date.	Food given in grains.	Weight of equal quantity of food kept for same time in grains.	Weight of larva in grains.	Food left in grains.	Excrement in grains.
10-IV	4	3·1	·1	2·3	·06
11-IV	moult.				
12-IV	5	4·3	·36	3·9	·12
13-IV	5	3·5	·7	2·9	·17
14-IV moult	5	4·5	·8	4·1	·18
15-IV	5	4·4	1·6	3	·3
16-IV	10	8·9	3·5	5·3	1·3
17-IV moult	15	14·1	3·9	12·2	·8
18-IV	15	13·7	6·5	8·6	1·8
19-IV	20	18·6	14·75	5·7	3·8
20-IV	30	27·8	24·2	8·2	8·4
21-IV moult	30	26	23·8	21·4	1·5
22-IV	50	47	41	17·7	10
23-IV	50	47	62·6	6·5	18·8
24-IV	100	94·5	94·2	10·6	48·1
25-IV	120	114	120·1	29·5	54·5
26-IV	90	83	126	23·8	66·1

Then it spun up.

Weight of pupa-cocoon 13 days after spinning 47·4 grains.

Male emerged 15th May.

Weight of pierced cocoon	8·2 grains.
,, dried larval exuvium	·2 ,,
,, pupal ,,	·9 ,,
,, cocoon	7·1 ,,
Floss	3·7 ,,
Shell	3·4 ,,

(B.)

Date.	Food given in grains.	Weight of equal quantity of food kept for same time in grains.	Weight of larva in grains.	Food left in grains.	Excrement in grains.
10-IV	4	3·1	·1	·05	2·6
11-IV	moult.				
12-IV	5	4·3	·35	·12	4·2
13-IV	5	3·5	·7	·25	3·5
14-IV moult	5	4·5	·7	·09	4·3
15-IV	5	4·4	1·45	·3	3·3
16-IV	10	8·9	3·2	1·1	5·9
17-IV moult	15	14·1	3·2	6	12·8
18-IV	15	13·7	5·35	1·4	9·2
19-IV	20	18·6	11·3	3	8·2
20-IV	30	27·8	21·3	6·4	10·3
21-IV moult	30	26	20·8	1·8	21·4
22-IV	50	47	32·9	7·3	25·8
23-IV	50	47	56·2	16·6	5·5
24-IV	100	94·5	85·5	38·9	24·5
25-IV	120	114	100·4	61·5	42
26-IV	90	83	91·6	58·9	33·6

Spun on the 27th.

Male emerged 14th May.

Weight of cocoon and pupa 13 days after spinning	36·8
,, ,, ,, pierced	6·8
,, ,, dried larval exuvium	·2
,, ,, ,, pupal ,,	·8
,, ,, cocoon only	5·8
,, ,, Floss	2·4
,, ,, Shell	3·4

(C.)

Date.	Food given in grains.	Weight of equal quantity of food kept for same time in grains.	Weight of larva in grains.	Food left in grains.	Excrement in grains.
10-IV	4	3·1	·1	2·4	·06
11-IV	moult.				
12-IV	5	4·3	·32	3·6	·10
13-IV	5	3·5	·65	3·2	·2
14-IV	5	4·5	·7	4·4	·15
15-IV	5	4·4	1·35	3·4	·3
16-IV	10	8·9	3·1	6·1	·8
17-IV	15	14·1	3·3	11·8	·7
18-IV	15	13·7	6·1	8·8	1·2
19-IV	20	18·6	12·5	7	3·9
20-IV	30	27·8	20	13·2	5·8
21-IV moult	30	26	19·5	24	1·3
22-IV	50	47	32·3	24·3	8·6
23-IV	50	47	52·2	5·8	19·8
24-IV	100	94·5	84·6	14·5	39·3
25-IV	120	114	98·3	37·6	59·6
26-IV	90	83	101	26	59·8

Spun on 27th.

Male emerged 14th May.

Weight of cocoon and chrysalis 13 days after spinning	38·8
,, ,, ,, pierced	6
,, ,, Larval exuvium	·2
,, ,, Pupal ,,	·9
,, ,, cocoon only	4·9
,, ,, Floss	2
,, ,, Shell	2·9

These figures illustrate clearly the daily growth of the larva, till it commences to spin : it attains a weight of over 100 grains, then spins and there is a loss of sixty grains at once probably mainly moisture from the skin but also from the silk and from exuvium at moulting. Actually only five grains of dried silk compose the cocoon. The total food fed was 554 grains, of which 196·2 was rejected and 200 grains of excrement were obtained. Actually in this case (No. 3), of about 550 grains of leaf fed, about 200 is waste, 200 is excrement : this has an importance in considering the manurial requirements of the castor crop, since if 110 maunds of leaf were picked per acre, 40 maunds of leaf and 40 maunds of excrement would be available per acre to go back. For further details, see the tables below for larger quantities of worms.

Records were kept very carefully for four worms and are as follows :—

	Food supplied in grains.	Food consumed in grains.	Excrement in grains.
(1) ..	645	348·7	215·93
(2) ..	645	379·8	241·33
(3) ..	645	297·8	198·31
(4) ..	645	319·2	201·61
TOTAL ..	2,580	1,345·5	857·18
Average for 1 worm	645.	336	214
For 10,000 worms,	115 mds. 7 srs.	60 mds.	38 mds. 8 srs.

In the above the weight of excrements shows the weight when the excrements were not dry.

Below are given actual figures for several broods; the food supplied was weighed fresh: the wasted leaves and excrements were weighed when they were dry or nearly dry:—

(1).	Leaves supplied	11 mds.
	,, wasted	1 md. 39 srs.
	Excrement	2 mds. 27 srs.
	Pierced cocoons secured ..	5½ srs.
	Approximate number of cocoons ..	13,278.
(2).	Leaves supplied	19 mds.
	,, wasted	3 ,, 14 srs.
	Excrement	3 ,, 36½ ,,
	Cocoons secured	9½ srs.
	Approximate number of cocoons and of worms which spun these cocoons	25,000.
(3).	Leaves supplied	49½ mds.
	,, wasted	5 ,, 30 srs.
	Excrement	12 ,,
	Cocoons secured	19 seers.
	Approximate number of cocoons ..	76,000.
	Eggs kept by weight about ..	120,000.
	(In this brood the mortality was very high at the time of spinning).	
(4).	Leaves supplied	77½ seers.
	,, wasted	16¼ ,,
	Excrement	12¾ ,,
	Cocoons got about	1 seer.
	Number of the cocoons	2,418.
	Eggs kept by weight about ..	5,550.
(5).	Leaves supplied	25 mds. 23½ srs.
	,, wasted	5 ,, 8½ ,,
	Cocoons	7½ seers.
	A large amount of leaves had to be supplied as they were drying quickly on account of the West winds.	
(6).	Leaves supplied	9 mds. 31 srs.
	,, wasted	2 ,, 16 ,,
	Cocoons	5¾ seers.
	Appproximate number of the cocoons	14,503.

Twenty-five cocoons (pierced) taken at random weigh as follows: —

1 weighs 8·0 grains.
1 ,, 7·7 ,,
1 ,, 7·6 ,,
3 weigh 7·2 ,,
1 weighs 6·8 ,,
1 ,, 6·7 ,,
2 weigh 6·6 ,,
2 ,, 6·5 ,,

4	weigh	6·4	grains.
2	,,	6·3	,,
2	,,	6·2	,,
3	,,	6·1	,,
1	weighs	5·8	,,
1	,,	5·2	,,

Average 6·5 or 1,077 to the lb.

The last was composed of :

Pupa case	1·3
Larval skin	·2
Cocoon	3·7
(Floss	·85)
(Shell	2·85)

Twenty-five unpierced cocoons, dead and dried, weighed as follows :—

19·1, 18·7, 18·0, 17·9, 17·7, 17·5, 16·9, 16·9, 15·4, 15·3, 14·3, 14·0. 13·7, 13·7, 13·3, 13·3, 13·0, 12·8, 12·3, 12·3, 11·8, 11·6, 11·2, 10·8, 10·1.

Average 14·4, or about 487 to the lb.

The heaviest was composed as follows :—

Pupa	12·4	
Larval skin	·3	19·1
Cocoon	6·4	
(Floss	2·15)	
(Shell	4·25)	

The lightest :

Pupa	5·6	
Larval skin	·3	10·1
Cocoon	4·2	
(Floss	1·2)	
(Shell	3·0)	

Figures of the weights of live unpierced cocoons are given above ; others are :

Pupa	39·9	
Larval skin	·25	45·4
Cocoon	5·25	
(Floss	1·5)	
(Shell	3·7)	

Pupa	30·8	
Larval skin	·5	36·3
Cocoon	5·0	

Below are given some more figures showing the percentage of larval and pupal exuvia in the pierced cocoons.

Weight of pierced cocoon.	Weight of silk obtained from same before boiling (*i.e.*, excluding the empty pupa case and the last larval moult).
6·2 grs.	5·1 grs.
6 ,,	5 ,,
8·2 ,,	7·1 ,,
6·8 ,,	5·8 ,,
6 ,,	4·9 ,,
5·2 ,,	3·7 ,,
7·5 ,,	6·4 ,,
5·4 ,,	4·2 ,,
51·3 ,,	42·2 ..

A lot of 100 cocoons weighing 641 grains contained 540 grs. of silk.

Therefore on an average the weight of the empty pupa cases and the last larval moults (which remain inside the pierced cocoons) is about 16 per cent. of the weight of the pierced cocoons. The same percentage is observed when larger numbers of cocoons are taken.

The following table gives figures for six worms of which the sex was noted :

No.	Maximum weight of larva.	Sex of Moth.	Weight of silk only.
1	84	Female	5·0
2	72	..	5·3
3	88	..	5·1
4	77	..	5·5
5	95	Male	5·3
6	72	..	4·3

History of the Pusa Broods.

The following account of broods gives the periods at different seasons, as well as other important facts :—

First Brood.—25th March 1907, seven couples of moths hatched from cocoons obtained in Kamrup, Assam. They laid about 2,000 eggs (by weight) between the 27th and 31st March. These eggs hatched between the 4th and 10th of April, the worms spun cocoons between the 20th and 28th April and moths emerged again from the 7th to 15th April. One moth laid 415 eggs, another 188, another 354 ; the average for well-fed healthy moths is about

300. Four individual worms of this brood were recorded separately :

Eggs laid	31·III.	31·III.	31·III.	31·III.
,, hatched	8·IV.	8·IV.	8·IV.	8·IV.
Cocoon formed	26·IV.	26 IV.	26·IV.	26·IV.
Moth emerged	15·V.	14·V.	14·V.	14 V.
	45 days.	44 days.	44 days.	44 days.

Second Brood.

Eggs laid	9-V to 15-V.
,, hatched	17-V to 22-V.
Cocoons formed	5-VI to 17-VI.
Moths emerged	22-VI to 27-VI.
	44 days.

In this brood the cocoons were small, 4,000 to the seer, owing to the difficulty of getting food which had to be carted five miles and which was not fed fresh to the worms, owing to the time taken in carting and to its not being procurable as wanted. About 40,000 cocoons were obtained.

Third Brood.

Eggs laid	24-VI to 1-VII
,, hatched	1-VII to 9-VII.
Cocoons formed	17-VII to 27-VII.
Moths emerged	2-VIII to 14-VIII.
	38 days.

In this brood, 13,278 cocoons were obtained, but about 700 moths failed to emerge from the cocoons (a sign of weakness) and rats ate or cut about 950. Nearly 500 worms died before spinning, mostly when quite young. The cocoons were larger, the worms being fed from a plot of castor nearer at hand and about 2,500 went to the seer. About $10\frac{3}{4}$ maunds of leaf were fed to this brood, thus making about 83 maunds of leaf to 100,000 worms which would produce a maund of pierced cocoons. For this brood, details are given of the daily food supplied, as a guide to the amount required. which of course increases as the worms increase in size.

9-VII	Leaves	3 seers.	14 chittacks.
10-VII	Leaves	5 seers.	14 ,,
	Wastage ..		11 ,,

	Excrement	..			5	chittacks.
11-VII	Leaves ..	..	12 seers.			
	Wastage	..			12	,,
	Excrement	..			10	,,
12-VII	Leaves ..	..	11	,,	6	,,
	Wastage	..	1	,,	2	,,
	Excrement	..	1	,,	2	,,
13-VII	Leaves ..	..	11	,,	8	,,
	Wastage	..	1	,,		
	Excrement	..	1	,,	6	,,
14-VII	Leaves ..	..	17	,,	10	,,
	Wastage	..	1	,,	4	,,
	Excrement	..	1	,,	2	,,
15-VII	Leaves ..	..	22	,,		
	Wastage	..			6	,,
	Excrement	..	1	,,	8	,,
16-VII	Leaves ..	..	41	,,	13	,,
	Wastage	..	2	,,	6	,,
	Excrement	..	6	,,		
17-VII	Leaves ..	..	41	,,	10	,,
	Wastage	..	3	,,	10	,,
	Excrement	..	12	,,		
Spinning commenced (500 Spun).						
18-VII	Leaves ..	..	39	,,	10	,,
	Wastage	..	3	,,	8	,,
	Excrement	..	7	,,	8	,,
Spinning continued (776 Spun).						
19-VII	Leaves ..	..	25	,,	10	,,
	Excrement and Wastage	..	20	,,	8	,,
Spinning continued (1,090 Spun).						
20-VII	Leaves ..	..	44	,,	4	,,
	Wastage	..	7	,,	10	,,
	Excrement	..	9	,,	6	,,
	Dead 12.					
21-VII	Leaves ..	..	31	,,	14	,,
	Wastage	..	5	,,	10	,,
	Excrement	..	13	,,	2	,,
Spinning continued (1,500 spun).						
	Dead 80.					
22-VII	Leaves ..	..	36		5	,,
	Wastage	..	10	,,	4	,,
	Excrement	..	16	,,	12	,,
Spinning continued (1,444 Spun).						
	Dead 107.					
23-VII	Leaves ..	..	37	,,	6	,,
	Wastage	..	8	,,	7	,,
	Excrement	..	8	,,	14	,,
Spinning continued (800 Spun).						
	Dead 73 (partly eaten by rats).					
24-VII	Leaves ..	..	40 seers.		13	,,
	Wastage	..	4	,,	12	,,
	Excrement	..	6	,,	6	,,

Spinning continued (1,200 Spun).
Dead 24.
4 eaten by rats.
5 died at moult.
15 diseased.

25-VII	Leaves	15 seers.	4 chittacks.
	Wastage ..	9 ,,	2 ..
	Excrement ..	6 ,,	4 ,,

Spinning continued (1,200 Spun).
Dead : 5 failed to spin.
6 ; rats ate them.
13 failed to moult.
13 diseased.

26-VII	Leaves	9 seers.	10 chittacks
	Wastage ..	9 ,,	12
	Excrement ..	3 ,,	

Spinning continued (1,435 Spun).
Dead : 12 ; rats ate them.
3 failed to moult
13 could not spin
10 diseased.

27-VII	Leaves	4 seers.	3 chittacks.
	Wastage ..	1 seer	
	Excrement ..		8 ,,

Spinning continued (340 Spun).
Dead : 8 ; rats ate them.
12 could not spin.

The above figures show several interesting points ; they are not complete for the whole brood, but they show how the feeding has to be done and what weight of matter is obtained as excrement and wastage which should all go back to the land as manure. The disease was also a distinct factor both in worms that declined to spin and those that died at moults.

Fourth Brood.

Eggs laid	4-VIII to 19-VIII.
Eggs hatched	10-VIII to 26-VIII.
Cocoons formed	26-VIII to 10-IX.
Moths emerged	10-IX to 26-IX.
	37 days.

For this brood, 49,000 eggs by weight were kept ; 100 eggs weigh 2·5 grains. Only 25,000 cocoons were obtained since over 20,000 worms died before or at the first moult, 1,500 died when full-grown, and 1,000 could not spin. To secure the $9\frac{1}{2}$ seers of cocoons, 18

maunds 37 seers of leaf were supplied, giving only 76 maunds of leaf to the maund of silk; there was thus no real loss, estimating from the amount of leaf used.

The following is the detailed record of each day :—

Eggs. 4 to 19 Aug.	Larvæ hatched. 10 to 26 Aug.	Pupated. 26 Aug. to 10 Sept.	Emerged. 10 to 26 Sept.

	Food supplied.			Food wasted.			Excrement.			Dead.	Picked for spinning.	Worms which could not spin among the picked.
	Md.	sr.	ch.	Md.	sr.	ch.	Md.	sr.	ch.			
14-VIII	0	5	14	0	0	6		..				..
15-VIII	0	7	0	0	1	8		..		..	..	..
16-VIII	0	5	12	0	4	0		..		..	..	..
17-VIII	0	6	4	0	3	8		..		..	..	..
18-VIII	0	7	0	0	3	0		..		21	..	..
19-VIII	0	11	14	0	2	0				25	..	..
20-VIII	0	18	0	0	2	0	0	0	13	30	..	..
21-VIII	0	22	0	0	3	8	0	1	8	22	..	..
22-VIII	0	21	0	0	4	0	0	2	0	33	..	..
23-VIII	0	26	0	0	5	8	0	4	0	40	..	..
24-VIII	1	6	0	0	3	0	0	5	0	50	..	..
25-VIII	1	12	0	0	3	8	0	5	8	95	..	..
26-VIII	1	24	0	0	1	8	0	6	12	80	1,200	..
27-VIII	2	0	0	0	12	0	0	20	8	74	2,400	..
28-VIII	1	13	8	0	22	0	0	14	0	54	5,000	..
29-VIII	1	8	8	0	12	0	0	18	0	73	5,200	10
30-VIII	0	32	0	0	10	0	0	6	0	81	2,000	65
31-VIII	0	36	0	0	4	0	0	8	0	78	1,000	
1-IX	0	38	8	0	6	0	0	7	0	86	300	
2-IX	1	12	12	0	4	2	0	12	4	83	500	73
3-IX	0	36	0	0	7	8	0	15	2	91	1,600	21
4-IX	0	21	0	0	7	12	0	13	8	35	2,400	314
5-IX	0	19	0	0	5	8	0	11	0	25	2,100	111
6-IX	0	6	0	0	4	2	0	4	0	22	800	56
7-IX	0	2	8	0	1	3	0	0	12	15	260	25
8-IX	0	0	12	0	3	0	0	0	8	19	125	10
9-IX	0	0	6	0	0	3	0	0	2	5	60	18
10-IX	0	0	0							11		

Fifth Brood.

Eggs laid	.. ..	13-IX to 26-IX.
,, hatched	.. ..	20-IX to 3-X.
Cocoons formed	.. ..	5-X to 26-X.
Moths emerged	.. ..	21-X to 16-XI.

To this brood about fifty maunds of leaf were given, about 76,000 cocoons were obtained, but about 45,000 worms died, 30,000 just before pupation; this was due to overcrowding, as an attempt was being made to get as large a brood as the rearing house could take, and secondly, to the difficulty of getting food,

as it had to be collected from villages miles away, was hours on the road and could only be got twice a day. Overcrowding, lack of attention, irregular feeding and fermenting food played havoc with the worms and the cocoons only weighed 4,000 to the seer.

The detailed record is as follows :—

Eggs 13 to 26 Sept. Hatched 21 Sept. to 3 Oct. Pupated 5 to 26 Oct. Moths 21 Oct. to 16 Nov.

Date.	Food supplied.			Food wasted.			Excrement.			Dead.	Picked for spinning.	
	Md.	sr.	ch.	Md.	sr.	ch.	Md.	sr.	ch.			
23-IX	0	2	8		..			..		10	....	
24-IX	0	3	0	0	0	8		..		25	....	
25-IX	0	10	8	0	2	0		..		85	....	
26-IX	0	14	2	0	1	14	0	1	2	95	....	
27-IX	0	28	12	0	3	8	0	2	2	51	....	
28-IX	0	35	8	0	7	0	0	2	4	31	....	
29-IX	0	38	4	0	8	8	0	4	2	49	....	
30-IX	1	14	4	0	6	8	0	17	0	85	....	
1-X	1	32	0	0	7	12	0	20	4	96	...	Up to this date leaves were got from the ¾ acre plot.
2-X	2	1	12	0	5	8	0	25	0	112	....	
3-X	2	26	8	0	4	8	0	28	4	..	....	
4-X	2	36	4	0	5	4	0	34	12	145	....	
5-X	2	21	4	0	3	0	0	31	0	200	800	
6-X	1	3	0	0	2	12	0	22	12	221	5,400	
7-X	2	12	0	0	3	4	0	33	4	261	8,850	
8-X	1	28	0	0	5	12	0	14	12	382	8,000	
9-X	1	30	0		..			..		2,600	2,250	
10-X	1	20	0		..			..		4,080	2 200	
11-X	1	20	0	0	6	0	0	11	0	2,370	500	
12-X	1	20	0	0	8	0	0	13	0	200	500	
13-X	1	26	0	0	6	8	0	16	12	356	150	
14-X	1	30	0	0	6	0	0	16	0	394	....	
15-X	2	17	0	0	3	0	0	17	0	276	65	
16-X	2	0	0	0	5	0	0	20	2	643	820	
17-X	2	2	0	0	2	0	0	26	8	605	3,500	
18-X	1	20	0	0	4	0	0	16	6	590	5,300	
19-X	1	10	0	0	3	0	0	11	0	600	5,300	
20-X	1	20	0	0	4	0	0	15	0	1,500	2,900	
21-X	2	31	0	0	7	0	0	15	0	2,510	2,000	
22-X	1	22	0	0	31	0	0	21	0	6,200	2,100	
23-X	1	5	0	0	18	0	0	16	0	5,000	2,900	
24-X	0	32	0	0	22	0	0	12	0	3,960	3,100	
25-X	0	26	0	0	16	0	0	8	0	5 235	1,300	

Sixth Brood.—There being little castor available, small broods were kept, and an attempt was made to space them out so that there should be always some in all stages, and not immense numbers in one stage, all requiring immense quantities of food at once as they got mature.

	Eggs laid.	Eggs hatched.	Cocoons formed.	Moths emerged.
(1)	23-X	1-XI	27-XI to 2-XII	*9 to 16-1-08
(2) & (3)	2-XI	9-XI	10 to 22-XII	*17 to 28-1
(4)	9-XI	22-XI	8 to 26-I	28-II (first)
(5)	14 to 22-XI	28-XI to 9-XII	26-1 to 3-II.	10-III (first)

Date.	Food supplied.			Leaves wasted.			Excrement.			Dead.	How many picked for spinning.
	Md.	sr.	ch.	Md.	sr.	ch.	Md.	sr.	ch.		
2-XI	0	0	1								
3-XI	0	0	1		..			..		2	
4-XI	0	0	1		..			..		2	
5-XI	0	0	2		..			..		3	
6-XI	0	0	2		..			..		4	
7-XI	0	0	3		..			..		6	
8-XI	0	0	3		..			..		18	
9-XI	0	0	3		..			..		4	
10-XI	0	0	4		.			..		2	
11-XI	0	0	4		..			..		4	
12-XI	0	0	4		..			..		4	
13-XI	0	0	$4\frac{1}{2}$	0	0	1		..		11 (4 cut by	
14-XI	0	0	$4\frac{1}{2}$	0	0	2		..		something).	
										3	
15-XI	0	0	$4\frac{1}{2}$	0	0	$1\frac{1}{2}$		..		1	
16-XI	0	0	7	0	0	$1\frac{1}{2}$	0	0	$\frac{1}{2}$	..	
17-XI	0	0	8	0	0	$1\frac{1}{2}$	0	0	$\frac{1}{2}$	2	
18-XI	0	0	13	0	0	$\frac{1}{2}$	0	0	$\frac{1}{2}$	2	
19-XI	0	0	7		..		0	0	$1\frac{1}{2}$	..	
20-XI		..			.			..		3	
21-XI	0	0	7	0	0	2	0	0	1	1	
22-XI	0	1	3	0	0	2	0	0	1	..	
23-XI	0	1	12	0	0	8	0	0	4	1	
24-XI	0	2	4	0	0	9	0	0	$5\frac{1}{2}$	3	
25-XI	0	1	8	0	0	3	0	0	5	..	
26-XI	0	1	12	0	0	$3\frac{1}{4}$	0	0	6	4 could not	100
27-XI	0	1	14	0	0	5	0	0	9	moult.	
										..	265
28-XI	0	1	10	0	0	$5\frac{1}{2}$	0	0	11	..	216
29-XI	0	0	9	0	0	6	0	0	$4\frac{1}{2}$	..	57
30-XI	0	0	$3\frac{1}{2}$	0	0	$3\frac{1}{2}$	0	0	$1\frac{3}{4}$	1	24
1-XII	0	0	1	0	0	$1\frac{1}{2}$	0	0	$\frac{1}{2}$	1 cut by	6
2-XII	0	0	$\frac{1}{2}$		..			..		something.	
										11 missed.	
3-XII		..			..			..			
TOTAL	0	18	$\frac{1}{2}$	0	3	$8\frac{3}{4}$ 0	0	3	$4\frac{1}{4}$		

674 cocoons in all :

6 sent to I. E.; they also spun.

2 could not spin.

* These were artificially hurried by heating in a closed moist chamber. 77 seers of leaf were supplied and 1 seer of cocoons secured ; the detailed records are attached.

Moths (except 81) emerged by heating between 9 and 16-I-08. Three cocoons spun on 1-XII were kept separate and not heated. Moths came out from these between 21 to 24-I-08.

1,000 eggs kept by weight. Laid 2 Nov. Hatched 9 Nov. 119 did not hatch.

Date.	Food supplied.			Food wasted.			Excrement.			Dead.	How many picked for spinning.
	Md.	sr.	ch.	Md.	sr.	ch.	Md.	sr.	ch.		
9-XI	0	0	1		..			..		..	
10-XI	0	0	1		..			..		..	
11-XI	0	0	2		..			..		9	
12-XI	0	0	2		..			..		12	
13-XI	0	0	2	0	0	½		..		8	
14-XI	0	0	2	0	0	½		..		13	
15-XI	0	0	2	0	0	½		..		23	
16-XI	0	0	2	0	0	½		..		16	
17-XI	0	0	2	0	0	½		..		18	
18-XI	0	0	2½	0	0	½		..		14	
19-XI	0	0	1	0	0	½		..		1	
20-XI	(2nd moult)				..			..		..	
21-XI	0	0	2	0	0	½	0	0	½	12	
22-XI	0	0	3	0	0	⅓	0	0	⅓	4	
23-XI	0	0	3	0	0	½	0	0	¾	4	
24-XI	0	0	3	0	0	½	0	0	¾	..	
25-XI	(3rd moult).				..			..		2	
26-XI	0	0	3	0	0	¼		..		5	
27-XI	0	6	0	0	0	½	0	1		..	
28-XI	0	0	10	0	0	1	0	0	½0	4	
29-XI	0	0	9	0	0	1	0	0	2½	?	591 counted living to-day.
30-XI	0	0	1	0	0	1½	0	0	¾		
1-XII	0	0	1		..			..		4th moult.	
2-XII	0	0	6	0	0	2½	0	0	½	..	
3-XII	0	0	13	0	0	2	0	0	½	23 destroyed.	568 counted living ; rest cut & eaten by rats.
4-XII	0	1	0	0	0	3½	0	0	1	5 missing.	
5-XII	0	0	13	0	0	1½	0	0	1½	2 missing.	4 sent to office as diseased living.
6-XII	0	1	0	0	0	2½	0	0	2½	1	
7-XII	0	1	4	0	0	2½	0	0	4	..	
8-XII	0	1	4	0	0	2½	0	0	4	1	
9-XII	0	1	4	0	0	3½	0	0	1	..	
10-XII	0	1	4	0	0	4	0	0	8½	2 rat cut.	18 ; 554 living
11-XII	0	1	4	0	0	3	0	0	7	2	173
12-XII	0	0	10	0	0	?	0	0	3	..	147
13-XII	0	0	3	0	0	1	0	0	½	5	74
14-XII	0	0	2	0	0	½	0	0	½	1	24
15-XII	0	0	2	0	0	½	0	0	½	2	10
16-XII	0	0	1½	0	0	½	0	0	¼	15	6
17-XII	0	0	1½	0	0	¾	0	0	¼	..	15
18-XII	0	0	1½	0	0	½	0	0	¼	5	5
19-XII	0	0	¾	0	0	¼	0	0	⅛	4	4
20-XII	0	0	¾	0	0	¼	0	0	⅛	4	5
21-XII	0	0	½	0	0	¼		..		8	4 ; 20 counted living.
22-XII	0	0	¼	0	0	⅛		..		3	
23-XII	0	0	⅛		..			..		3	
24-XII		..			..			..		2	
25-XII		..			..			..		6	

1,000 eggs aid 2 Nov.—kept by counting. Hatched 9 Nov. 89 did not hatch.

Date.	Food supplied.	Food wasted.	Excrement.	Dead.	Picked for spinning.	REMARKS.
	Md. sr. ch.	Md. sr. ch.	Md. sr. ch.			
9-XI	0 0 1	..	..	..	..	
10-XI	0 0 1	..	..	..	..	
11-XI	0 0 2	..	..	..	..	
12-XI	0 0 2	..	..	1	..	
13-XI	0 0 2	0 0 ½	..	4	..	
14-XI	0 0 2	0 0 ½	..	3	..	
15-XI	0 0 2	0 0 ½	..	3	..	
16-XI	0 0 2¼	0 0 ½	..	6	..	
17-XI	0 0 2	0 0 ½	..	10	..	
18-XI	0 0 2½	0 0 ½	..	5	..	Second moult.
19-XI	0 0 1½	0 0 ½	..	6	..	
20-XI	..	..	..	..	..	
21-XI	0 0 2	0 0 ½	0 0 ½	6	..	
22-XI	0 0 3	0 0 ⅓	0 0 ⅓	6	..	
23-XI	0 0 3½	0 0 ½	0 0 ¾	1	..	Third moult.
24-XI	0 0 5	0 0 1	0 0 ½	..	..	
25-XI	..	..	..	..	..	
26-XI	0 0 2	..	..	9	..	
27-XI	0 0 7	0 0 1½	0 0 ½	1	..	Fourth moult.
28-XI	0 0 12	0 0 1¼	0 0 1¼	2	..	
29-XI	0 0 15	0 0 2	0 0 1¾	4	..	
30-XI	0 0 1	0 0 2½	0 0 1½	..	..	
1-XII	0 0 1½	..	..	..	..	
2-XII	0 0 5½	0 0 1½	0 0 ½	2	..	
3-XII	0 0 13	0 0 1½	0 0 ½	2 cut by rat.	..	
4-XII	0 1 0	0 0 3	0 0 1	..	..	
5-XII	0 1 0	0 0 2½	0 0 1½	29 cut 1 dead.	..	704 counted living.
6-XII	0 1 0	0 0 3½	0 0 3	33 cut 4 dead.	..	679 „ „
7-XII	0 1 8	0 0 4½	0 0 3	21 cut 4 dead.	..	666 „ „
8-XII	0 1 8	0 0 5½	0 0 3	11 cut 2 dead.	..	654 „ „ Rats poisoned.
9-XII	0 1 8	0 0 5	0 0 3¾	12 cut	..	
10-XII	0 1 8	0 0 4½	0 0 7	4 cut	..	
11-XII	0 1 4	0 0 4	0 0 5½	..	26	
12-XII	0 0 15	0 0 4	0 0 5	1 dead	159	
13-XII	0 0 6	0 0 2	0 0 1	3	205	
14-XII	0 0 3	0 0 1	0 0 ½	..	67	
15-XII	0 0 3	0 0 1	0 0 ½	..	39	
16-XII	0 0 2	0 0 ½	0 0 ¼	..	17	
17-XII	0 0 2	0 0 ½	0 0 ¼	2	15	
18-XII	0 0 2	0 0 ¾	0 0 ¼	1	36	
19-XII	0 0 1	0 0 ⅛	0 0 ¼	..	14	
20-XII	0 0 ¾	0 0 ¼	0 0 ⅛	1	4	
21-XII	0 0 ½	0 0 ¼	..	2	8	
22-XII	0 0 ¼	0 0 ⅛	..	..	7	
23-XII	0 0 ⅛	..	..	..	..	
24-XII	..	..	..	1	..	
25-XII	..	..	..	2	..	

2,000 eggs kept (by weight). Laid 9 Nov. Hatched night 22 Nov.

Date.	Food supplied.			Food wasted.			Excrement.			Dead.	Picked for spinning.	REMARKS.
	Md.	sr.	ch.	Md.	sr.	ch.	Md.	sr.	ch.			
23-XI	0	0	½		..				..	..	....	
24-XI	0	0	1	0	0	¼			..	..	....	
25-XI	0	0	1½	0	0	½			..	..	....	
26-XI	0	0	1½	0	0	½			..	..	....	
27-XI	0	0	1½	0	0	½			..	..	....	
28-XI		..			..				..	..	....	First moult.
29-XI		..			..				..	..	....	
30-XI	0	0	1		..				..	..	....	
1-XII	0	0	1½	0	0	½			..	1	....	
2-XII	0	0	1½	0	0	¼			..	..	....	531 counted living.
3-XII	0	0	2	0	0	½			..	..	....	
4-XII	0	0	4	0	0	¼			..	2	....	
5-XII	0	0	4	0	0	1½			..			
6-XII	0	0	3	0	0	1			..	1	....	
7-XII	0	0	2	0	0	1			..	..	....	
8-XII		..			..				..	..	....	Second moult.
9-XII	0	0	2	0	0	1			..	..	....	
10-XII	0	0	3	0	0	1½	0	0	¼	3	....	
11-XII	0	0	3	0	0	1	0	0	¼	..	....	
12-XII	0	0	4	0	0	1	0	0	¼	..	....	
13-XII	0	0	6	0	0	¾	0	0	¼	..	....	
14-XII	0	0	6	0	0	1½	0	0	½	..	....	
15-XII	0	0	4	0	0	1	0	0	½	4	....	
16-XII		..			..				..	1	....	Third moult.
17-XII	0	0	3	0	0	1¼	0	0	½	..	....	
18-XII	0	0	2	0	0	½	0	0	¼	5	....	512 counted living.
19-XII	0	0	3	0	0	¼	0	0	¼	..	....	
20-XII	0	0	5	0	0	½	0	0	½	..	....	
21-XII	0	0	5	0	0	¼	0	0	½	2	....	
22-XII	0	0	5	0	0	¾	0	0	¾	..	....	
23-XII			..	0	0	3		..		1	....	
24-XII			..	0	0	¾	0	0	¼	..	....	
25-XII			..			..		..		..	....	
26-XII	0	0	1			..		..		..	....	
27-XII	0	0	2			..		..		6	....	
28-XII	0	0	5	0	0	1	0	0	½	..	....	Fourth moult.
29-XII	0	0	6	0	0	1	0	0	¾	8	....	
30-XII	0	0	9	0	0	1½	0	0	1½	..	....	Counts up to moult
31-XII	0	0	12	0	0	1½		..		..	....	
1-I-08	0	0	12	0	0	1½	0	0	1½	3	....	Counts up to moult.
2-I	0	0	12	0	0	1½	0	0	1½	1	....	
3-I	0	0	13	0	0	2	0	0	1½	2	....	
4-I	0	0	15	0	0	2½	0	0	1½	1	....	
5-I	0	1	0	0	0	3¼	0	0	1¾	..	....	
6-I	0	1	0			2¼	0	0	2¼	..	....	
7-I	0	1	0			3	0	0	2¼	3	....	
8-I	0	1	0	0	0	3½	0	0	2¼	..	8	
9-I	0	0	15	0	0	3½	0	0	2½	..	67	
10-I	0	0	10	0	0	3¼	0	0	2	1	121	
11-I	0	0	8	0	0	4½	0	0	1½	..	102	
12-I	0	0	4	0	0	3	0	0	1	..	73	
13-I	0	0	2	0	0	1	0	0	½	..	39	
14-I	0	0	1	0	0	½	0	0	½	..	15	
15-I	0	0	1	0	0	½	0	0	½	..	9	
16-I	0	0	½	0	0	¼	0	0	¼	..	2	
17-I	0	0	¼	0	0	..		..		..	1	

19-I	12 still living—are full-grown—not eating well, also not spinning probably on account of extreme cold.	
24-I	.. ..	8
25-I	.. ..	2
26-I	.. ..	2

About 550 eggs laid between 14 to 22 Nov. were kept. They hatched between 28 Nov. and 9 Dec. 412 worms were found to be living on 18 Dec., some in the first and some in the second stage.

Date.	Food supplied.			Food wasted.			Excrement.			Dead.	Picked for spinning.	Remarks.
	Md.	sr.	ch.	Md.	sr.	ch.	Md.	sr.	ch.			
18-XII			..			..			..	..	....	412 counted living.
19-XII	0	0	1	0	0	⅛	0	0	⅛	3	....	
20-XII	0	0	1¼	0	0	¼	0	0	⅛	2	....	
21-XII	0	0	1½	0	0	¼	0	0	⅛	4	....	
22-XII	0	0	2	0	0	¼	0	0	⅛	2	....	
23-XII	0	0	2	0	0	¼	0	0	⅛	3	....	
24-XII	0	0	2	0	0	½	0	0	¼	4	....	
25-XII	0	0	2	0	0	½	0	0	¼	4	....	
26-XII	0	0	2	0	0	½	0	0	¼	..	....	
27-XII	0	0	2	0	0	½	0	0	¼	5	....	
28 XII	0	0	2	0	0	½	0	0	¼	..	....	
29-XII	0	0	¼	0	0	⅛	0	0	⅛	1	....	
30-XII	0	0	¼	0	0	⅛	0	0	⅛	..	....	
31-XII	0	0	1½	0	0	¼	0	0	⅛	1	....	
1-I	0	0	2	0	0	½	0	0	¼	..	....	
2-I			2	0	0	¾	0	0	¼	1	....	
3-I	0	0	3	0	0	½	0	0	¼	1	....	
4-I	0	0	3	0	0	¾	0	0	¼	2	....	
5-I	0	0	4	0	0	1	0	0	½	1	....	
6-I	0	0	4	0	0	1	0	0	¾	..	....	
7-I	0	0	4	0	0	¾	0	0	½	2	....	
8-I	0	0	4	0	0	1¼	0	0	½	1	....	
9-I	0	0	3	0	0	½	0	0	¼	..	....	Resting for moult.
10-I	0	0	2	0	0	½	0	0	¼	2	....	
11-I	0	0	½	0	0	½	0	0	¼	2	....	
12-I	0	0	2	0	0	½	0	0	½	2	....	
13-I	0	0	2	0	0	½	0	0	½	1	....	
14-I	0	0	4	0	0	¾	0	0	½	1	....	
15-I	0	0	4	0	0	1	0	0	½	2	....	
16-I	0	0	4	0	0	1	0	0	½	..	....	
17-I	0	0	4	0	0	1	0	0	¾	4	....	
18-I	0	0	4	0	0	1	0	0	¾	2	....	
19-I	0	0	4	0	0	½	0	0	¾	2	....	
20-I	0	0	4	0	0	1	0	0	¾	..	....	
21-I	0	0	4	0	0	½	0	0	¾	5	....	
22-I	0	0	4	0	0	½	0	0	¾	..	....	
23-I	0	0	4	0	0	½	0	0	¾	..	....	
24-I	0	0	4	0	0	½	0	0	¾	5	....	
25-I	0	0	9	0	0	1½	0	0	1½	5	....	
26-I	0	0	12	0	0	1⅛	0	0	2	3	7	
27-I	0	0	12	0	0	2¼	0	0	2¼	4	15	
28-I	0	0	11	0	0	2½	0	0	2¼	15	37	11 out of the dead could not moult.
29-I	0	0	7½	0	0	3½	0	0	1½	16	41	
30-I	0	0	6	0	0	1½	0	0	1	9	28	
31-I	0	0	3	0	0	1½	0	0	5	5	34	
1-XII	0	0	3	0	0	½	0	0	¼	14	22	
2-XII	0	0	2	0	0	½	0	0	½	7	22	
3-XII	0	0	1	0	0	¼	0	0	¼	9	6	
4-XII			..			..			..	9	..	
Total		10	6		2	6½		1	15	161	212	

33 were thrown away as they were neither eating nor spinning. They were dying gradually. On cutting some of the worms which were dying, masses of undigested food were found in the abdomen. No other symptoms of any disease could be made out.

210 cocoons secured in all—2 could not spin.

Moths began to emerge 10 March.

The first three lots of worms in the sixth brood were given artificial heat in the pupal stage in order to hasten the emergence of the moths. The weather at the time was very cold, with cold winds blowing, and the temperature was as low as between 35°F. to 40°F. The cocoons were kept in a closed chamber in which the temperature was kept up to 80°F. to 100°F., and a high degree of moisture was produced by heating water so that the wet bulb thermometer recorded between 65 to 80. The results are shown below.

Date when the worms spun cocoons.	Date of commencement of the application of the artificial heat.	Date of emergence of moths.	Duration of the pupal stage in days.
27-11-07	7-1-08	9-1-08	43
10-12-07	7-1-08	17-1-08	38
11-12-07	7-1-08	17-1-08	37

Date and hour.	Dry bulb.	Wet bulb.	Per cent. of humidity.	REMARKS.
7-1-08 noon	75	..	..	Started.
,, 1 P.M	81	68	48%	
,, 2 P.M.	81	68	48%	
,, 3 P.M	83	73	60%	
,, 4 P.M.	91	76	48%	
8-1-08 6 A.M.	70	59	48%	
,, 10 A.M.	91	74	42%	
,, 11 A.M.	95	78	44%	
,, 12 noon	96	74	32%	
,, 2 P.M.	100	79	39%	
,, 3 P.M.	96	76	37%	
,, 6 P.M	93	75	40%	Moths emerged night 8-1-08.
9-1-08 7 A.M.	75	65	56%	
,, 10 A.M.	80	70	58%	
,, 1 P.M. to 4 P.M.	90	77	53%	
,, 8 P.M.	80	70	58%	
10-1-08 8 A.M.	90	74	44%	
,, 11 A.M.	90	81	66%	
,, 4 P.M.	85	75	61%	
,, 10 P.M.	85	75	61%	

Date and hour.	Dry bulb.	Wet bulb.	Per cent. of humidity.	Remarks.
11-1-08 8 A.M.	80	65	41%	
,, 1 P.M.	80	70	58%	
,, 4 P.M.	85	72	51%	
12-1-08 8 A.M.	80	70	58%	
,, 11 A.M.	85	76	64%	
,, 4 P.M.	85	76	64%	
13-1-08 9 A.M.	78	69	61%	
,, 1 P.M.	84	79	79%	
,, 4 P.M.	84	79	79%	
14-1-08 8 A.M.	83	74	63%	
,, noon	86	76	61%	
,, 4 P.M.	86	76	61%	After this no records were kept for each day but the thermometers were watched so that the dry bulb ranged between 70 and 90 degrees and the wet bulb between 60 and 80 degrees.
24-1-08 Stopped				

To the following no heat was applied and they were allowed to come out in the natural course.

Date when the worms spun cocoons.	Date of emergence of moths.	Duration of pupal stage in days.
1 Dec.	21 Jan.	52
8 Jan.	28 Feb.	51

SEVENTH BROOD—

Eggs laid.	Eggs hatched.	Worms spun.	Moths emerged.
*11 Jan.	4 Feb.	11 Mch.	31 Mch.
*25 Jan.	15 Feb.	20 Mch.	8 Apl.
2 Mch.	15 Mch.	9 Apl.	25 Apl.

In this brood, the effect of the disease on the weakly race is clearly seen; many eggs failed to hatch; many worms died and the results are very poor.

* (The first lots hastened by incubation.)

2,000 eggs laid 11 Jan.—kept by weight. Hatched 4 Feb. 350 did not hatch.

Date.	Food supplied.			Food wasted.			Excrement.			Dead.	Picked for spinning.	Remarks.
	Md.	sr.	ch.	Md.	sr.	ch	Md.	sr.	ch.			
4-II	0	0	¼		....			....		..		..
5-II	0	0	½		....			....		..		..
6-II	0	0	¾	0	0	¼	0	0	¼	..		..
7-II	0	0	¾	0	0	½	0	0	½	..		..
8-II	0	0	1	0	0	½		....		..		..
9-II	0	0	1	0	0	½		....		15		..
10-II	0	0	1¾	0	0	¾		....		12		..
11-II	0	0	2	0	0	¾		....		12		..
12-II	0	0	2	0	0	½		....		10		..
13-II		....		0	0	1		....		11		..
14-II		....			....			....		8		Moult.
15-II	0	0	½	0	0	½		....		..		..
16-II	0	0	1	0	0	½		....		16		..
17-II	0	0	2	0	0	½		....		10		..
18-II	0	0	3	0	0	½		....		24		..
19-II	0	0	3	0	0	1		....		17		..
20-II		....			....			....		19		Moult.
21-II		....		0	0	1½		....		12		..
22-II	0	0	6	0	0	1¾		....		14		..
23-II	0	0	6	0	0	1½		....		10		..
24-II	0	0	6	0	0	1		....		10		..
25-II	0	0	5		....			....		14		..
26-II		....			....			....		42		Moult. 1,125 counted living.
27-II	0	0	6	0	0	1¾		....		7		
28-II	0	0	9	0	0	1	0	0	¾	5		Contained in one basket 2′ diam. not overcrowded.
29-II	0	0	14	0	0	1	0	0	1¾	..		
1-III	0	0	12	0	0	1½	0	0	2½	16		
2-III	0	0	6	0	0	½	0	0	1	52		52 which were lagging behind, rejected .
3-III	0	0	½		....			....		..		Moult.
4-III	0	0	10	0	0	½	0	0	½	..		
5-III	0	1	0	0	0	2½		....		4		
6-III	0	1	8	0	0	3½		....		6		
7-III	0	2	4	0	0	2½		....		5+83		85 rejected, they were lagging behind, 917 counted left on 7 Mch.
8-III	0	2	4	0	0	3½		....		2		
9-III	0	2	4	0	0	4		....		3		
10-III	0	2	8	0	0	3½		....		..	110	
11-III	0	2	0	0	0	4		....		..	261	
12-III	0	1	12	0	1	8		....		6	215	
13-III	0	0	10	0	0	8		....		8	197	
14-III	0	0	2½	0	0	4½		....		3+24	41	24 rejected, not spun 5.
15-III		....		0	0	1½		....		1	4	

34,000 eggs laid between 20 to 30 Jan. Hatched between 13 to 18 Feb. About 6,100 did not hatch.

Date.	Food supplied.		Food wasted.		Excrement.		Dead.	Picked for spinning.	REMARKS.
	Sr.	Ch.	Sr.	Ch	Sr.	Ch.			
13-II	0	$\frac{1}{4}$	0	0	..				
14-II	0	$1\frac{1}{2}$	0	0	..				
15-II	0	3	0	0	..				
16-II	0	$5\frac{3}{4}$	0	$1\frac{1}{2}$	..				
17-II	0	$8\frac{3}{4}$	0	$2\frac{1}{2}$	..				
18-II	0	$9\frac{3}{4}$	0	$2\frac{1}{2}$	..				
19-II	0	15	0	$3\frac{1}{2}$	..				
20-II	1	8	0	$4\frac{1}{4}$	..				
21-II	1	10	0	$4\frac{1}{2}$	..				
22-II	1	2	0	$5\frac{3}{4}$	..				
23-II	0	12	0	5	..				
24-II	1	0	0	$8\frac{3}{4}$	..		41		
25-II	1	5	0	$9\frac{1}{2}$	..		62		
26-II	1	15	0	9	..		300		
27-II	2	6	0	12	..		250		
28-II	3	12	0	15	..		121		
29-II	3	7	1	1	..		71		
1-III	3	4	0	10	..		156		
2-III	6	12	0	13	..		146		
3-III	7	$9\frac{1}{2}$	1	4	..		40		
4-III	7	8	0	7	..		61		
5-III	7	1	1	0	..		47		
6-III	12	12	1	6	..		139		Mean percentage humidity at 8 A.M. from 6th to 17th March is 49%.
7-III	20	12	1	10	..		30		
8-III	23	2	2	3	..		99		
9-III	20	0	2	4	..		62		
					..				
10-III	20	0	2	7	..		197		Almost all dying at 3rd moult unable to moult.
11-III	20	0	2	8	..		126		
					..				
12-III	25	12	3	12	..		526		Almost all at 3rd moult. Leaves getting dry on account of West winds.
					..				
					..				
					..				
					..				
13-III	45	10	4	6	..		403		
14-III	40	2	7	8	..		131		
15-III	46	10	8	4	..		152		
16-III	55	1	8	10	..		121		
17-III	51	10	13	2	..		83	20	Percentage humidity rose and for next 12 days averaged 61·5%.
18-III	48	8	8	0	..		30	365	
19-III	47	0	10	6	..		97	1,937	
20-III	40	0	12	0	..		57	4,553	
21-III	22	0	6	0	..		97	5,428	
22-III	18	0	12	0	..		..	2,053	
23-III	14	0	5	0	..		63	1,081	
24-III	15	0	4	0	..		63	1,010	
25-III	5	0	$3\frac{1}{2}$	0	..		51	695	
26-III	2	8	$2\frac{1}{2}$	0	..		49	279	
27-III	1	3	0	10	..		37	197	
28-III	0	10	0	10	..		31	89	
29-III	0	6	0	3	..		59	32	59 rejected : 17,711 cocoons.
30-III	0	$2\frac{1}{2}$	0	1	..		36	8	36 rejected.
31-III	..		..		..		..	4	
1-IV	..		..		..		..	6	

408 grains of eggs (100 = 2·8 grs.). 13,750 eggs laid between 2 to 4 Mch. 08. Hatched 15 to 16 Mch. About 300 did not hatch and 400 rejected.

Date.	Food supplied. Sr.	Ch.	Food rejected Sr.	Ch.	Dead.	Picked for spinning.	REMARKS.
16-III	0	2	..				
17-III	0	2	..				
18-III	0	3	..				
19-III	0	5	..				
20-III	0	6	..		4		
21-III	0	5½	0	1½	140		
22-III	0	11½	0	1			Moulting.
23-III	1	6	0	2½	154		
24-III	0	4	0	2½	21		
25-III	0	10	0	1½	51		
26-III	2	½	0	2½	163		Moulting.
27-III	3	3	0	4	205		
28-III	2	5	0	8½			
29-III	4	11	0	14	76		Moulting.
30-III	13	½	0	13½	118		12,625 counted living to-day.
31-III	13	15	1	8	102		
1-IV	8	3	1	11	126		
2-IV	18	0			26		Moulting.
3-IV	30	0	5	0	270		
4-IV	36	0	6	12	154		
5-IV	39	0	6	8	138		
6-IV	48	9	7	½	166		
7-IV	45	2	9	8	131	672	
8-IV	16	3	11	14	102	3,543	
9-IV	11	0	9	0	92	3,777	
10-IV	8	0	3	0	115	1,122	
11-IV	6	0	3	0	81	437	
12-IV	..		2	0	40	207	
13-IV	..		..		76	208	
14-IV	..		..		17	113	
15-IV	..		..		37	94	
16-IV	..		..		26	46	
17-IV	..		..		31	4	
18-IV	..		..		46		
	..		..		rejected.		

Out of those picked for spinning 295 could not spin cocoons.
Moths began to emerge 24 Apl. 08.
Pierced cocoons secured 1 sr. 10 ch.

There is a practice of keeping the feeding trays with worms piled up one above the other. Feeding the worms in this way is rather convenient at the time when the dry winds blow and dry the leaves very quickly, because when the trays are piled up in this way, the leaves do not get dry so soon. In order to find out whether this has any injurious effect on the health of the worms, 12,000 worms were selected from the third lot in the seventh brood just after they passed out of the 3rd moult ; (1) 6,000 were fed in trays which were kept

piled up ; and (2) 6,000 in trays which were kept separate and open. The results were somewhat better in the first case as will be seen from the figures given below ; because the worms kept more moist and although the trays were piled up, they were not airtight and therefore hardly interfered with the breathing and evaporation from the body of the worms. In the wet season the trays should not be piled up in this way.

	1. 6,000 worms just after the 3rd moult fed in trays kept piled up.		2. 6,000 worms just after the 3rd moult fed in trays kept separate and open.	
Date.	Dead.	Picked for spinning.	Dead.	Picked for spinning.
30-III	29	..	61	..
31-III	24	..	47	..
1-IV	41	..	74	..
2-IV	Moult.	..	Moult.	..
3-IV	79	..	102	..
4-IV	58	..	87	..
5-IV	68	..	70	..
6-IV	70	..	66	..
7-IV	58	576	63	96
8-IV	58	2,292	33	1,251
9-IV	30	1,717	57	2,060
10-IV	48	332	56	790
11-IV	31	94	41	343
12-IV	7	19	28	153
13-IV	18	20	51	83
14-IV	3	..	7	29
15-IV	17	..	11	24
16-IV	13	..	9	7
17-IV	7 rejected.	..	17	2
	Out of these 4,865 cocoons secured. 113 could not spin. 659 dead and rejected. 363 missed.		Out of these, 30 rejected, 4,748 cocoons secured. 132 could not spin. 910 dead and rejected. 210 missed.	

Eighth Brood.

30,000 eggs were laid between 4 Apl. and 10 Apl. About 3,000 hatched between 12 Apl. and 19 Apl., but all the worms died before the first moult.

157,000 eggs were laid between 25 Apl. and 30 Apl. These eggs did not hatch, only 300 weak larvæ being obtained and they died before the first moult. So far as could be ascertained, the causes were the gradual weakening of the previous broods from disease (see below page 65), the injurious effect of the forced emergence of moths by

artificial heat in the previous brood and the hot dry weather, the temperature being up to 110°F. in the shade, the humidity low and a dust-laden west wind blowing, as is usual at this time.

A supply of cocoons (600) was obtained in a village near Palasbari, Kamrup, and brought to Pusa. They were isolated and examined ; only 41 moths hatched, all weak and it was found that there were abundant maggots and pupæ of a parasitic Tachinid fly. These were destroyed and the whole consignment burnt. A fresh supply was gathered consisting of 400 newly hatched worms, 2,700 eggs and 70 cocoons. These were isolated and the stock issued from quarantine only after careful examination and in the form only of healthy worms.

Ninth Brood.

2,700 eggs hatched 4 July 08.

They were fed, no record being kept of weights.

Date	Died.		Spun.
7-VII	17	..	
8-VII	25	..	
9-VII	20	..	
10-VII	22	..	
11-VII	34	..	
12-VII	35	..	
13-VII	16	..	
14-VII	33	..	
15-VII	18	89	327 from the 400 live worms.
16-VII	10	164	Moths emerged from 31 July.
17-VII	13	74	
18-VII	20		
19-VII	12		
20-VII	6	995	
21-VII	1	700	2,036 from 2,700 eggs.
22-VII	4	252	Moths emerged from 6 Aug. 08.
23-VII	..	63	
24-VII	..	26	

Tenth Brood.

In this brood four separate lots of eggs were kept and in all about 20,700 worms hatched out of the eggs. In all 16,148 cocoons were obtained.

The following are the detailed records. When the worms were made to spin, they got mixed up.

6,000 eggs of moths from white cocoons.
Laid 3 to 4 Aug. Hatched from 10 Aug. About 1,000 eggs did not hatch.

Date.	Approximate No. of worms being fed.	Dead.	Food supplied.	Food rejected.	Picked for spinning.	Remarks.
			Sr. Ch.	Sr. Ch.		
12-VIII	5,000	30				
13-VIII	5,000	18	..	..	..	First moult.
14-VIII	4,950	28	..	..	..	
15-VIII	..	..	..	..	..	
16-VIII	..	..	..	..	..	Second moult. These dead are all from the time of 1st
17-VIII	4,560	390	..	..	..	moult. They
18-VIII	4,529	31	..	..	..	were kept to
19-VIII	..	..	..	..	..	see if they
20-VIII	4,403	126	..	..	..	could revive.
21-VIII	..	..	..	..	..	
22-VIII	4,369	34	2 12	..	..	About half of
23-VIII	4,345	24	9 4	..	..	the dead could
24-VIII	4,333	12	13 0	1 9	..	pass the 1st
25-VIII	4,303	30	13 3	3 0	..	moult.
26-VIII	4,279	26	10 2	5 8	63	
27-VIII	4,237	42	6 7	1 6	1,544	
28-VIII	4,230	7	0 12	4 5	824	
29-VIII	4,219	11	0 6	0 5	150	
30-VIII	..	6	0 4	0 2	100	
31-VIII	..	2	..	0 1	68	
1-IX	..	3	..	..	14	
2-IX	..	..	..	..	4	Moths began to emerge 10 Sept.

Actually 2,780 cocoons were got.

6,000 eggs of moths from white cocoons.
Laid 7 Aug. Hatched 14 Aug. 08. About 1,300 did not hatch.

Date.	Approximate No. of worms being fed.	Dead.	Food supplied.	Food rejected.	Picked for spinning.	Remarks.
17-VIII	4,700		Sr. Ch.	Sr. Ch.	..	Moulting.
18-VIII	..	25	..	..	..	
19-VIII	..	..	..	..	..	
20-VIII	..	..	..	..	..	Moult.
21-VIII	4,250	430	..	..	..	Dying mainly
22-VIII	4,175	75	3 0	..	..	at moults.
23-VIII	4,163	12	7 15	1 4	..	
24-VIII	4,132	31	9 8	2 3	..	
25-VIII	4,096	36	6 15	1 14	..	
26-VIII	4,042	54	16 3	2 8	..	
27-VIII	3,977	65	18 11	2 4	..	
28-VIII	3,962	15	39 5	3 5	..	
29-VIII	3,937	25	26 10	7 6	1,518	
30-VIII	..	12	18 8	7 13	2,314	
31-VIII	..	7	7 0	2 4	1,132	
1-IX	..	3	4 8	3 8	350	
2-IX	..	10	1 8	2 11	228	
3-IX	..	7	0 11	0 14	80	5,624
4-IX	..	4	0 1	0 6	24	5,684
5-IX	..	..	..	..	..	
6-IX	..	..	..	..	..	

Actually 5,582 cocoons were got and 64 could not spin.

7,000 eggs from moths from brown cocoons.

Laid 8 to 10 Aug. 08. Began to hatch 15 Aug. All hatched.

Date.	Approximate No. of worms being fed.	Dead.	Food supplied.	Food rejected.	Picked for spinning.	REMARKS.
19-VIII	..	..	Sr. Ch.	Sr. Ch.	..	Moulting.
20-VIII	..	..	..	..	..	
21-VIII	..	137	..	..	..	Dead mainly those which could not moult.
					..	
					..	
22-VIII	..	113	1 7	..	..	
23-VIII	..	33	2 14	0 8	..	
24-VIII	..	40	3 14	0 10	..	
25-VIII	..	8	4 15	1 3	..	
26-VIII	..	51	3 10	0 16	..	
27-VIII	..	115	10 7	0 14	..	
28-VIII	..	8	11 5	2 4	..	
29-VIII	.	24	10 6	2 4	..	
30-VIII	..	10	19 3	3 14	37	
31-VIII	..	6	10 0	3 5	1,345	
1-IX	..	4	7 5	4 5	1.600	
2-IX	..	4	1 1	4 4	644	
3-IX	..	1	0 12	0 10	84	3,710
4-IX	..	5	..	0 11	28	3,738
5-IX	..	..	..	..		
	..	..				

Actually 3,530 cocoons were got and 68 could not spin.

5,000 eggs of moths from white cocoons.

Laid 13 Aug. 08. Began to hatch 21 Aug. About 1,000 did not hatch.

Date.	Approximate No. of worms being fed.	Dead.	Food supplied.	Food rejected.	Picked for spinning.	REMARKS.
	Md. sr. ch.	..	Md. sr. ch.	Md. sr. ch.	..	
25-VIII	..	..	0 0 10	..	..	
26-VIII	..	132	0 0 12	0 0 3	..	
					..	Dead ones are mostly those which were lagging behind and are therefore rejected.
					..	
					..	
					..	
	..	..	..	..	..	
27-VIII	..	138	0 2 4	0 0 3	..	
28-VIII	..	9	0 3 9	0 0 10	..	
29-VIII	..	35	0 4 8	0 0 11	..	
30-VIII	..	13	0 6 8	0 0 13	..	
31-VIII	..	20	0 8 6	0 0 15	..	
1-IX	..	12	0 12 4	0 1 3	..	
2-IX	..	9	0 16 6	0 2 6	..	
3-IX	..	17	0 11 11	0 2 13	568	
4-IX	..	18	0 5 0	0 3 4	1,032	
5-IX	..	..	0 2 3	0 1 8	750	
6-IX	..	..	..	0 0 12	..	2,350

Actually 2,350 cocoons were got and 18 could not spin.

Eleventh Brood.

Eggs kept—

25,000	laid	13 to 15 Sept. 08.
40,000	,,	14 to 16 Sept. 08.
30,000	,,	17 Sept.
31,000	,,	18 ,,
22,000	,,	19 ,,
23,000	,,	20 ,,
7,000	,,	21 ,,
178,000		

Began to hatch 21 Sept. 08
,, ,, spin 6 Oct. 08.
Moths began to emerge 25 Oct. 08.

Such a large number of worms was purposely kept in this brood for using up the castor leaves. The worms could not be accommodated in the silkworm house, therefore a part of the potato storage house was used.

In this brood were secured—

Pierced cocoons, 34 srs. 6 ch.
Unpierced ,, 11 ,, 4 ,,

About 3,500 pierced cocoons made up a seer, and unpierced cocoons 1,800. Therefore about 140,550 worms were reared.

Twelfth Brood.

Two lots were reared in this brood. The detailed records are given below—

27 Oct. 15,000 eggs laid
Hatched 6 Nov.

Spun	10 Dec.	90
	11 ,,	866
	12 ,,	1,716
	13 ,,	1,520
	14 ,,	760
	15 ,,	450
	16 ,,	248
	17 ,,	125
	18 ,,	78
	19 ,,	40
	20 to 6 Dec.	100
	23 to 25 ,,	200
		6,193

In this lot many worms were eaten by rats. Also when it became cold, the worms died in the same manner as last year, *viz.*, they

could not moult properly and died. The skins could not be shed and usually remained encircling the last segments.

Moths began to emerge 16 Jan. 09 to 4 Feb. 09.

Eggs laid 14 Nov. Hatched 26 Nov. 08.

Date.	Leaves supplied.			Dead.			
	Md.	sr.	ch.				
26-XI-08	..	..	..	..			Hatched. The counts in this lot were not kept from the beginning.
24-XII-08	0	0	13	58			
25-XII	0	0	12	156			
26-XII	0	0	13	62			3,340 counted living on this date.
27-XII	0	0	9	37			
28-XII	0	0	12	25			
29-XII	0	0	14	11			
30-XII	0	1	0	28			
31-XII	0	1	1	7			
1-I-09	0	1	14	21			
2-I	0	1	13	28			
3-I	0	2	8	16			
4-I	0	0	8	12			
5-I	0	2	6	17			
6-I	0	1	14	13			
7-I	0	1	13	12			
8-I	0	2	5	16			
9-I	0	2	10	15			
10-I	0	2	13	18			
11-I	0	2	2	5			
12-I	0	4	2	25			
13-I	0	4	3	40			
14-I	0	7	10	66			
15-I	0	9	6	35	10	spun.	
16-I	0	8	10	63	126	,,	
17-I	0	7	14	37	252	,,	
18-I	0	6	10	25	150	,,	
19-I	0	5	12	50	139	,,	
20-I	0	3	4	72	342	,,	
21-I	0	2	5	110	198	,,	
22-I	0	1	8	120	125	,,	
23-I	0	0	9	155	50	,,	
24-I	0	0	6	52	12	,,	
25-I	0	0	4	10	4	,,	

Twenty-five living—lived on for some time—were neither eating nor spinning. All died.
Moths began to emerge 24 Feb. 09.

THIRTEENTH BROOD.

It has been seen that intense cold (like intense heat) weakens the worms, and as they feed for a very long period in winter they are more liable to disease than in summer. Just after the winter a period of very dry hot weather follows and the effect on the worms is very bad. This bad effect is noticeable in the first lots reared in this brood. In

order to revive the stock, therefore, a fieldman was sent to Assam to procure some more seed in March 1909. He came back with about 20,000 eggs and eighty seed cocoons. The eggs were not so good and hatched very unsatisfactorily, only about 1,500 worms hatching out in all. The seed cocoons were very good this time and not diseased or flimsy like those got previously. About 1,000 eggs were got from worms reared at Nagpur. The Pusa stock and that got from Assam were reared in separate lots, and it remained to be seen whether the weakened race would revive itself with the fall of rain.

Thirteenth Brood.—9,000 eggs laid ..	20 Jan. 09. Hatched 9 Feb. 21 .. .. 11 .. 23 .. .. 14 ..	7,000 hatched 20 Feb.
30,000	23 .. .. 16 ..	

Date.	Food supplied.	Food wasted.	Excrement.	Dead.	Picked for spinning.	Remarks.
	Sr. Ch.	Sr. Ch.	Sr. Ch.			
16-II	..	..	..	40	..	
17-II	..	..	..	78	..	
18-II	..	..	..	75	..	
19-II	0 15	..	..	51	..	
20-II	1 6	0 4	..	110	..	
21-II	0 12	0 4	..	88	..	
22-II	..	..	..	..	..	
23-II	..	..	..	..	..	
24-II	..	..	..	..	..	
25-II	0 12	0 6	..	172	..	
26-II	0 12	0 8	..	4,552	..	
27-II	0 15	0 8	..	12,570	..	Percentage humidity fell below 50, and the average to the first week of April was under 40, see records below.
28-II	1 1	0 10	..	6,725	..	
1-III	1 3	0 9	..	4,910	..	
2-III	1 2	0 12	..	95	..	
3-III	1 4	0 14	..	15	..	
4-III	0 14	0 8	..	12	..	
5-III	1 8	0 11	..	90	..	
6-III	1 13	0 7	..	114	..	
7-III	1 12	0 8	..	110	..	
8-III	2 1	0 9	..	75	..	
9-III	2 9	0 11	..	68	..	The average percentage humidity for March was 33 per cent. (taken at 8 A.M.)
10-III	3 2	0 13	..	34	..	
11-III	3 6	1 1	..	53	..	
12-III	2 7	0 6	..	35	..	

Date.	Food supplied.		Food wasted.		Excrement.	Dead.	Picked for spinning	REMARKS.
13-III	1	12	0	12	..	26	..	
14-III	2	5	0	6	..	17	..	
15-III	3	6	0	6	..	34	..	
16-III	3	10	0	11	..	28	..	
17-III	6	2	2	4	..	24	..	
18-III	7	8	2	2	..	109	49	
19-III	9	0	2	12	..	35	168	
20-III	5	5	2	14	..	25	354	
21-III	5	0	1	8	..	25	290	
22-III	4	7½	1	4	..	14	185	
23-III	3	0	1	8	..	30	330	
24-III	2	0	0	12	..	12	161	
25-III	1	8	0	12	..	20	92	
26-III	0	12	0	3½	..	30	76	
27-III	0	8	0	3	..	25	52	
28-III	0	8	0	3	..	8	31	
29-III	0	5	0	3	..	10	24	
30-III	0	4	0	1½	..	11	24	
31-III	..		..		..	..	..	
22,800 eggs laid 1 to 4 Mch. 09. Hatched 12 to 15 Mch. 09. (About 12,000 failed to hatch.)								
28-III	0	8	0	4	..	108	..	
29-III	1	0	0	6	..	150	..	
30-III	1	3	0	5	..	42	..	
31-III	0	14	0	4	..	40	..	
1-IV	1	8	0	5	..	36	..	
2-IV	1	12	0	6	..	34	..	
3-IV	4	0	1	2	..	24	..	
4-IV	4	3	1	3	..	16	..	
5-IV	4	13	0	12	..	20	..	
6-IV	4	5	0	12	..	8	..	
7-IV	5	0	1	8	..	11	..	
8-IV	7	0	1	10	..	8	..	
9-IV	7	6	1	4	..	12	..	
10-IV	8	0	1	10	..	10	169	
11-IV	8	3	1	8	..	13	734	
12-IV	7	0	1	10	..	20	586	
13-IV	4	0	0	11	..	15	275	
14-IV	3	0	0	10	..	11	306	
15-IV	2	0	0	6	..	18	165	
16-IV	0	8	0	3	..	16	45	
17-IV	0	4	..		..	8	50	
18-IV	0	3	..		..	6	48	
19-IV	..		..		..	5	11	
20-IV	..		..		..	..	21	
21-IV	..		..		..	..	15	
22-IV	..		..		..	..	10	
							2,429	cocoons.

Moths began to emerge 28 Apl. 09.

Fourteenth Brood.

36,000 eggs laid 3 May 09. Hatched 10 May 09. (90 per cent. hatched.)

1st Moult 12th May.
2nd ,, 14th, 15th May.
3rd ,, 18th, 19th ,,
4th ,, 21st, 22nd ,,

Brought forward.

Spinning—	5,700	27th May.
	8,350	28th ,,
	3,400	29th
	3,050	30th ,,
	1,272	31st ,,
	346	1st June.
	170	2nd ,,
	100	3rd ,,
	60	4th ,,
	20	5th ,,
Total	22,468	

Weight of pierced cocoons, 7 seers 9 ch.; 30 per cent. worms died, of which 800 at and 2,800 after second moult. Average temperature, maximum in shade for May 1909, 102·6, humidity 64 per cent. This brood was from the stock that had come through the cold weather and previous rains.

Fifteenth Brood.

165,000 eggs kept. 90 per cent. hatched.

There was a very serious shortage of leaf, and leaf was brought many miles and in irregular quantity.

Eggs laid 14th to 18th June.

,, hatched 22nd, 23rd, 24th June.

Spinning began 7th July.

The mortality on eight consecutive days of spinning was—

Date.	No. dead.	No. spun.
7th July	11,740	140
8th ,,	10,991	3,300
9th ,,	10,800	7,700
10th ,,	10,999	10,800
11th ,,	10,750	8,300
12th ,,	8,000	10,250
13th ,,	4,500	4,800
14th ,,	3,300	6,300
15th ,,	1,500	4,250

In all—79,245 died, 68,340 spun.

The deaths were due to inability to spin at the proper time owing to insufficient food during the last stage.

Sixteenth Brood.

Eggs laid 27th July to 4th August.

Eggs hatched 2nd August to 11th August.

Worms spun 17th to 25th August.

Of 26,000 worms hatched, 23,973 spun cocoon.

New (M) Brood.—A second lot was started with outside seed—

Eggs laid 19th July.

,, hatched 25th July.

Worms spun 10th August.

Of 4,500 hatched, 4,242 spun cocoons.

New (B) Brood.—Eggs laid 23rd to 26th July.

,, hatched 29th July to 1st August.

Worms spun from 13th August.

Of 30,000 hatched, 28,206 spun.

Seventeenth Brood.

Eggs laid 16th September.

Eggs hatched	23rd September.
1st Moult	25th ,,
2nd ,,	27th ,,
3rd ,,	30th ,,
4th ,,	3rd October.
Spun	7th ,,

Of 24,000 worms, 64 per cent. died, and 8,700 spun. There was an outbreak of disease.

Second M. Brood.—Eggs laid 29th to 31st August.

,, hatched 5th to 7th September.

1st Moult	7th September.
2nd ,,	10th ,,
3rd ,,	13th ,,
4th ,,	16th ,,
Spun	19th ,,

Of 30,000 worms, 26,727 spun cocoons.

Second B. Brood.—Eggs laid 7th September.

,, hatched 13th ,,

1st Moult	15th ,,
2nd ,,	19th ,,
3rd ,,	22nd ,,
4th ,,	25th ,,
Spun	27th onwards.

Of 18,000 hatched worms, 16,655 spun cocoons.

Third M. Brood.—Eggs laid	9th	October.
,, hatched	16th	,,
1st Moult	18th	,,
2nd ,,	21st	,,
3rd ,,	25th	,,
4th ,,	29th	,,
Spinning began	2nd	November.

Of 22,500 worms hatched, 15,234 spun cocoons.

After this brood no definite records of this kind were kept and the worms have continued in regular broods; owing to the distribution of seed and the mixing of other seed, the course of the regular broods has not been kept up, and we have three or four broods going on at once. The biggest single brood reared has been one of about 150,000, and that is the full capacity of the rearing house.

Labour for Rearing.

From April 1907 to December 1908 (21 months), about 100 seers of pierced cocoons were produced. For producing this quantity of silk there have been absolutely necessary about 950 cooly days (including care of eggs, rearing of the worms, cleaning and sorting of the cocoons and plucking leaves from plots near by; excluding getting leaves from other villages and a night watchman if separately necessary).

With this may be compared the figures of the two big broods reared at Pusa (including and excluding the items as in the above).—

(1). For one brood occupying 69 days from the first day of oviposition till the cleaning and sorting of the pierced cocoons, and yielding about 19 seers of pierced cocoons; absolutely necessary, 240 cooly days. In this brood the mortality was unusually high at the time of spinning; had it not been for this about 30 seers of cocoons would have been secured.

(2). The second brood occupied about 79 days; yielded about 1 maund of pierced cocoons. Absolutely necessary, about 300 cooly days.

DISEASE, INFLUENCE OF CLIMATE, Etc.

Before discussing this point, we may recapitulate briefly the experience obtained at Pusa with individual broods. The first brood was from the 31st March to 14th May ; it was healthy and did well ; it must be noted that the seed was direct from Assam. The next brood was from 14th May to about 24th June. The cocoons were small but the worms and moths healthy. The third brood was from the end of June to the 10th August ; about 5 per cent. of moths did not emerge, and 3 per cent. died. The cocoons were larger. The fourth brood carried on into September and 40 per cent. of worms died before the first moult, 3 per cent. at maturity and 2 per cent. failed to spin. The fifth brood went on into November and nearly 60 per cent. of the worms died, while there was very great overcrowding, and the leaf was brought long distances as none was available. The cocoons were also small and poor (usually they are large at this season). The next went through the cold months ; to get eggs, the cocoons were artificially kept warm. The brood from these eggs was bad, 12 per cent. of the eggs not hatching, and only about fifty per cent. spinning in one lot, and in all the percentage was about this. The seventh brood was still worse, about 35 per cent. of cocoons being got in one lot, and 50 per cent. in another. The weather was now warming up, dry west winds blowing. The next brood gave about 75 per cent. of cocoons, but the produce from it in the first stage was annihilated by the dry hot west winds presumably, acting upon the eggs produced from disease. It must also be remembered that the whole broods were the descendants of seven couples of moths originally. In the ninth brood from fresh seed, we got 80 per cent. of cocoons and 75 per cent. : this occurring

during July; the tenth brood gave eighty per cent., the next in September gave over 75 per cent., and the following one in November-December only 50 per cent.

In Pusa, the minimum temperature during December oscillates in the forties and so far as can be seen, this is the most serious factor. If worms are coming on to spin during times when the temperature falls below 50° F., then it is likely that many worms will die. On the other hand, temperatures above 105° F. are also injurious, but more to the quality than to the output of cocoons. The *ideal* conditions seem to lie in temperatures between 60 and 90, possible conditions between 50 and 100, and difficult conditions, necessitating great care, when the temperature goes for any long period over 100, or under 50. The last is especially serious in the case of worms spinning or moths emerging; worms require a temperature of over 60° F., preferably over 70° F., for three days, in which to spin; moths require the same in order to couple. At no other stage is cold serious: with a minimum temperature of under 50° F., the pupæ remain healthy in the cocoons, the eggs remain healthy and do not hatch, and the young worms remain healthy, feeding little; but if cold overtakes worms spinning, or moths coupling and egg-laying, the temperature must be kept up to 70° F. at least, and if possible up to 75° F. for three days.

We give here the mean monthly temperatures at Pusa, recorded by the Imperial Agricultural Chemist during the whole time we have been rearing eri silk, so as to afford data for comparing any district with Pusa, for which records of broods are given above. The humidity is taken at 8 A.M.

Months.		Mean Temperatures.		
		Maximum.	Minimum.	Humidity.
May,	1906	98·6	76·2	66%
June,	,,	96·5	78·4	78·9%
July,	,,	90·9	79·9	88%
August,	,,	87·0	78·5	88%
September.	,,	91·4	79·4	83%

Months.		Mean Temperatures. Maximum.	Minimum.	Humidity.
October,	1906	88·7	72·3	83%
November,	,,	83·5	59·9	81%
December,	,,	....	51·0	88%
January,	1907	....	51·4	89%
February,	,,	....	53·4	88%
March,	,,	....	57·1	74%
April,	,,	92·3	66·4	65%
May,	,,	98·0	73·5	64%
June,	,,	93·2	78·0	82%
July,	,,	87·9	78·7	92%
August,	,,	89·7	79·0	88%
September,	,,	90·6	77·2	89%
October,	,,	90·2	70·3	85%
November,	,,	84·7	58·3	83%
December.	,,	77·2	48·85	81%
January	1908	66·6	45·9	83%
February,	,,	77·3	51·9	82%
March,	,,	90·4	58·6	57%
April,	,,	103·9	72·3	52%
May,	,,	100·8	75·5	69%
June,	,,	98·7	79·7	78%
July,	,,	93·0	79·3	84%
August,	,,	93·8	78·3	84%
September,	,,	93·2	77·05	85%
October,	,,	93·08	66·07	71%
November,	,,	86·2	53·8	72%
December.	,,	78·6	45·1	82%
January,	1909	78·6	48·1	77%
February.	,,	82·5	47·9	67%
March.	,,	97·0	59·7	33%
April,	,,	94·3	68·6	67%
May,	,,	102·6	75·4	64%
June,	,,	91·5	77·6	86%
July,	,,	90·8	79·2	86%
August,	,,	88·1	77·7	86%
September,	,,	90·7	78·2	85%
October,	,,	89·0	69·3	83%
November,	,,	84·6	58·8	84%
December.	,,	75·9	50·0	91%

In the following list of localities the months are given in which the mean maximum is over 100° F., and we take those months to be unsuited to rearing, as also the months when the minimum is below 50° F., as then the worms will develop slowly, will not easily spin cocoons and the moths will not couple. In the latter case either the young worms or the pupæ in the cocoons must be expected to rest, or if there are worms spinning or moths emerging, the house must be warmed and kept at a temperature of 70° F., if possible. These months are therefore not well suited to extensive rearing.

The temperature figures are taken from Vol. XVII of the Indian Meteorological Memoirs and are stated to be usually averages of 25 years, in no case less than ten years.

Chittagong	
Silchar	
Barisal	
Narayanganj	
Mymensingh	
Saugor Island	
Calcutta	
Jessore	
Berhampore	.. April 100°.
Bogra	
Sibsagar	.. January 49·5.
Dhubri	
Burdwan	.. April 100·6.
Patna	.. April 100·6, May 100·2.
Gaya	.. April 103·4, May 104·9, (June 99·6).
Benares	.. April 103·1, May 105·5, June 100·1, December 48·2, January 48·2.
Jalpaiguri	....
Dinajpur	.. January 49·4.
Purnea	.. January 48·3, December 49·7.
Darbhanga	.. (Pusa is in this District, but records lower minima and higher maxima).
Gorakhpur	.. April 100·4, May 101·0, January 49·2.
Bahraich	.. May 103·0, (April 99·6), December 48·0, January 47·1.
Bareilly	.. (April 99·3), May 103·2, (June 99·7), December 46·0, January 46·1, February 49·7.
Roorkee	.. (April 98·2), May 102·8, June 100·4, November 49·8, December 43·5, January 44·4, February 47·7.
Umballa	.. May 105·2, June 101·4, December 43·5, January 43·3, February 47·8.
Ludhiana	.. May 104·4, June 104·8, December 44·0, January 44·3, February 47·5.
Sialkot	.. May 103·1, June 105·5, November 49·9, December 42·5, January 42·8, February 46·1.
Rawalpindi	.. June 102·8, November 43·3, December 37·1, January 37·9, February 41·4.
Dehra Dun	.. December 45·6, January 44·8, February 47·0.
Allahabad	.. April 103·8, May 107, June 101·7, December 47·8, January 47·9.
Lucknow	.. April 102·4, May 105·0, June 100·5, December 46·2, January 46·7.
Cawnpore	.. April 102·2, May 106·2, June 101·1, December 47·6, January 47·1.
Mainpuri	.. April 102·5, May 107·5, June 101·2, December 47·3, January 46·1.
Agra	.. April 102·6, May 107·2, June 104·3, December 48·8, January 48·6.
Meerut	.. May 103, June 100·6, December 44·7, January 45·0, February 48·4.
Delhi	.. May 104·7, June 103·2, December 48·9, January 47·9.
Lahore	.. (April 108·2), May 105·7, June 107·4, July 100·6, November 46·8, December 40·3, January 40·7, February 44·1.
Peshawar	.. June 105·9, July 102·9, (August 99·2), November 45·1, December 39·0, January 39·6, February 42·6.

Dehra Ismail Khan ..	May 104·2, June 108·0, July 103·4, August 101·1, September 100·5, November 47·0, December 40·1, January 40·4, February 44·9.
Montgomery ..	April 100·1, May 108·3, June 110·0, July 104·7, August 102·0, September 101·7, December 43·0, January 42·2, February 46·4.
Multan ..	May 106·6, June 107·8, July 103·8, August 100·7, September 100·3, December 44·4, January 43·3, February 47·5.
Sirsa ..	April 101·1, May 107·2, June 106·7, July 100·5, November 49·5, December 42·7, January 43·1, February 46·8.
Bikaneer ..	April 101·3, May 107·1, June 106·5, July 100·4. January 49·4.
Pachpadra ..	April 106·3, May 107·8, June 105·7, December 46·3, January, 45·1, February 48·9.
Karachi	....
Hyderabad (Sind) ..	April 102·7, May 106·9, June 104·2.
Jacobabad ..	April 103·1, May 111·6, June 112·7, July 107·8, August 103·8, September 103·5, December 44·0, January 43·3, February 48·5.
Quetta ..	September 49·5, October 38·3, November 32·1, December 29·7, January 29·3, February 31·7, March 40·0, April 46·3.
Chaman ..	June 100·2, July 101·5.
Trivandrum ..	....
Cochin ..	....
Calicut ..	....
Mangalore ..	....
Mercara ..	....
Karwar ..	....
Goa ..	....
Marmugoa ..	....
Ratnagiri ..	....
Bombay ..	....
Surat ..	April 100·1.
Bhavnagar ..	April 100·8, May 102·9.
Veraval ..	....
Rajkot ..	April 102·8, May 105·4, (June 99·8).
Bhuj ..	April 101·0, May 101·3.
Ahmedabad ..	April 105·4, May 107·1, (June 99·4).
Deesa ..	April 104·2, May 106·7, June 101·9.
Tinnevelly ..	April 100·4.
Madura ..	April 100·1.
Trichinopoly ..	April 101·1, May 101·8, (June 99·0).
Coimbatore ..	....
Salem ..	April 100·7.
Mysore ..	....
Bangalore ..	....
Hassan ..	....
Chitaldroog ..	..
Cuddapah ..	March 101·7, April 105·2, May 106·3, June 100·3.
Kurnool ..	March 100·9, April 103·6, May 104·8.
Bellary ..	March 100·3, April 103·4, May 102·4.
Raichur ..	April 102·1, May 103·4.
Hyderabad (Deccan) ..	April 102·0, May 103·8.
Gulbarga ..	(March 99·2), April 103·2, May 104·8.
Belgaum ..	....
Bijapur ..	(April 99·8), May 100·3.
Sholapur ..	March 100·4, April 104·8, May 104·8.

Poona ..	April 101·6, (May 99·2).
Ahmednagar ..	(April 98·9, May 99·4).
Malegaon ..	April 103·2, May 104·0.
Buldana ..	April 100, May 101·1.
Chikalda ..	....
Akola ..	(March 99·2), April 106·0, May 107·7.
Amraoti ..	(March 98·1), April 105·0, May 107·7.
Khandwa ..	April 104·8, May 106·5.
Nagpur ..	April 105·5, May 109·3, (June 98·3).
Indore ..	April 100·6, May 102·8, December 49·3, January 49·8.
Neemuch ..	April 100·9, May 104, December 49·5, January 48·7.
Ajmere ..	(April 99·3), May 103·8, June 100·5, December 45·6, January 45·5, February 49·4.
Sambhar ..	April 100·4, May 105·1, June 102·3, December 46·3, January 45·4, February 49·7.
Jaipur ..	April 101·7, May 106·6, June 102·5, December 49·1, January 48.
Saugor ..	April 101·5, May 105·1.
Sutna ..	April 101·7, May 105·5, December 47·1, January 47·6.
Nowgong ..	April 103·4, May 107·4, June 101·6, December 46·4, January 47.
Jhansi ..	April 104·2, May 108·2, June 102·8.
Hoshangabad ..	April 104·8, May 107·6.
Pachmarhi ..	December 45·7, January 47·5.
Jubbulpore ..	April 102, May 105·6, December 46, January 48.
Seoni ..	April 101·1, May 103·9, December 49·8.
Chanda ..	April 106·5, May 109·5, (June 98·5).
Raipur ..	April 104·3, May 107·4.
Sambalpur ..	April 104·3, May 106·9.
Chaibassa ..	April 103·6, May 105·1.
Ranchi ..	(May 99·6).
Hazaribagh ..	(May 99·2).
Balasore ..	....
Cuttack ..	April 102, May 101·6.
Gopalpur ..	....
Waltair ..	....
Cocanada ..	May 100·7.
Masulipatam ..	May 100·1.
Nellore ..	April 100·9, May 106, June 101·8.
Madras ..	....
Cuddalore ..	....
Negapatam ..	....

Disease.

Examination of the records of broods above will show that there were periods when large numbers of worms died. These are attributed to want of leaf or bad leaf or to bad management, but are in the end directly due to disease, brought on by bad management. It is said that eri silkworms suffer from the diseases of mulberry silkworms, *viz.*, pebrine, flacherie, grasserie, muscardine.

We note below concerning these, but *flacherie as such* does not exist in eri nor could it; flacherie in mulberry silkworms is stated to be connected with *Streptococcus* and *Vibrio* from the mulberry leaf or at any rate with bacilli living in mulberry leaf in the insect's stomach. A disease of a similar nature connected perhaps with the castor leaf occurs in eri; we may call this "flacherie" but this must inevitably give rise to confusion. We prefer to call it "bacillar disease," as conveying at least a definite idea apart from flacherie and associating the name with one symptom. This disease is being investigated at present by the Imperial Agricultural Bacteriologist, Mr. C. M. Hutchinson. We do not propose to deal with it here, but to discuss it in a later publication.

Pebrine.

In one brood, worms died with symptoms pointing to pebrine. The presence of pebrine was suspected by Dr. Butler and was confirmed by the examination of worms and moths by Mr. MacNamara, Assistant Director of Sericulture, Kashmir. The disease has not assumed any real importance and we have not as yet found any necessity for microscopic examination of moths.

Muscardine.

In one lot of worms from seed imported from another locality, the worms died from a disease showing the symptoms of Muscardine; this is the only occasion on which this disease has appeared and it did not affect other broods going on at the same time. Disinfection of all trays and baskets is the important thing in this case.

The Fly Parasite.

The most important enemy to this silkworm is the parasite, a fly of the family *Tachinidæ* whose maggot lives in the worm and destroys it. This insect is at present limited in its distribution and it would be extremely unwise to introduce it to new localities. Cocoons should never be obtained, but eggs; the eggs cannot carry parasites, only the worms or cocoons can do so, and we would most

strongly urge that, if seed is required to commence or to invigorate, only healthy eggs should be obtained and never cocoons. In any case it is unwise to import cocoons from Assam at all, as they are obtainable from other parts of India where the parasite does not occur.

Other Enemies.

Rats are determined destroyers of the eri silk insect in all stages, and if the worms are being reared in an infested building, precautions are required. A plentiful use of traps and rat-poisons is usually sufficient ; the cocoons before emergence of the moth are specially attacked and they may require to be kept in closed baskets hung from a string.

Ants are fond of the young worms and the legs of the *machans* may require to be tarred or smeared with Crude Oil Emulsion, which effectively keeps off ants.

In one case it was found that bats came in at night and cut the cocoons, feeding on the pupa ; this is only to be avoided by preventing access of bats at all.

The Importance of Disease.

Until eri silk has been cultivated on a large scale for a longer period, the importance of disease cannot be estimated. We have had outbreaks of all forms of disease in one brood or another of several going on together, but not in all at one time. Rearers in Tirhoot have lost worms from disease, but in almost all cases bad feeding, bringing leaf long distances, or some other irregularity may have been the predisposing cause ; there is little real information about the diseases of eri silkworms and the names of the disease of mulberry silkworms, most like that from which the eri worms are suffering, are used rather indiscriminately to denote what may be quite different diseases in eri silk. So far as our experience goes up to now, with proper feeding, clean trays, proper spinning methods, disease is not very important unless the climatic conditions are really unsuitable ; if very dry hot weather sets in with a dry wind full of dust, disease may overcome the worms and the

mortality may be very large. So also with worms in the last stage and at spinning if the temperature is below 60° F. indoors. On the other hand, we have not had long enough experience to tell really how far disease is important and the question will have to be kept in view. *We would recommend all rearers to have their names and addresses registered for exchange of seed ;* a register is maintained at Pusa of all rearers known to us and so far as possible we arrange for exchange of seed between rearers in different localities.

In this connection the following circular has been issued :—

Eri Seed Supply.

An essential feature of good rearing is the exchange of seed and renewal of the stock from some distant place. Arrangements have been made for seed supply from several places ; as the demand for seed is fluctuating and not easy to arrange, it is essential to get the co-operation of as many rearers as possible. We propose to arrange as far as possible for the following :—

(1) Seed supply at fixed prices from certain centres.

(2) Register names of those who will want seed and the times they will want it.

(3) Register those willing to supply seed, either at a fixed rate or by exchange with a rearer in another place.

The rate proposed for the sale of seed is as follows :—

200	0	8
500	0	12
1,000	1	0
5,000	1	8
10,000	2	0
16,000 (1 oz.)	2	8
32,000 (2 oz.)	3	8

Those who are prepared to enter into this arrangement should (1) agree to the above scale ; (2) inform me in advance when they expect to have surplus seed for sale ; (3) inform me in advance when they expect to have surplus seed that they wish to exchange ; (4) inform me in advance when they will want to purchase seed ; (5) inform me at once if they wish to have a fresh supply of seed

every year at one season and expect to have surplus seed every year at another season.

The benefit of these arrangements to rearers will be great: in the first place, all rearers in some districts will want seed in July and will have surplus seed in March; others will want seed in March and have surplus seed in July-August; large rearers will have large surpluses of eggs for sale at different seasons and in some localities seed can be obtained and is required at all times; another benefit will lie in exchanging seed from widely separated localities, *e.g.*, Gujarat and Behar, South India and North India, etc.

Pusa can no longer supply all the seed, but if rearers desirous of coming into this arrangement will register their names, requirements and outturn of surplus seed, we will endeavour to put those requiring seed into touch with those supplying it.

In this connection, we would draw very special attention to the fact that many rearers, beginning from a good healthy stock, have in a few broods got disease, while other rearers with the same stock, have not had disease. We believe this to be wholly due to bad and good feeding respectively; and as a general rule with those who have started rearing eri silk during the last year, those who have fed often, giving good leaf in good condition at frequent intervals, have produced fine cocoons and a healthy stock, while those who have fed badly or have been careless have very largely had their stocks wiped out by disease.

In the Pusa rearings given above, the serious shortages of leaf have always led to large outbreaks of disease, and comparing these broods with broods of other places who got their seed from Pusa, there has been a marked superiority in the cocoons from rearers outside and they have also produced a far finer stock.

In Assam, where eri silk-rearing is general, there is much disease, but the industry is a subsidiary cottage one and disease does not matter very much. Also it must be remembered that the loss of the worms is far less important than with other kinds of silkworm, as in eri all the moths can be allowed to lay eggs without

loss of cocoons, whereas every moth allowed to emerge in tasar or mulberry silk means a cocoon unreelable.

Results obtained by rearers who have obtained seed from Pusa have varied immensely: some have been quite successful, some have failed; our own experience has been that eri silkworms are far more difficult to rear than mulberry silkworms, doing the two side by side in the same rearing house, so that there is either an inherent difference in the species or something vitally wrong in the food, the conditions or some treatment or else the disease is the important factor. The last is the controlling factor at present, and until it has been worked out, we must anticipate losses from disease and renew our seed periodically, ceasing cultivation altogether when the want of leaf, bad leaf or adverse climatic conditions compel us to.

It has been seen that climatic conditions have much to do with whether disease will prevail at all. The same stock which suffers badly from disease in April and May gives good results in July-August. On several occasions a number of worms has been picked out of a lot, diseased and dying in April-May and kept in a humid condition. They have been successfully reared, although some of them have been fed with leaves soaked in the juice of the body of diseased and dead worms. If the climatic conditions are favourable, the worms will normally resist the disease provided proper conditions of management and food-supply are kept up.

TREATMENT OF COCOONS.

Reeling, Cleaning, Boiling off, Carding, Spinning, Weaving, Bleaching, Dyeing.

Reeling.

It has been assumed in the past that eri, being an open cocoon, could not be reeled. There are two reasons given for this : one that the thread is not continuous, ending constantly at the open mouth ; the other that the cocoon being open, will, when placed in hot water for reeling, fill with water and sink, rendering reeling, as ordinarily practised, difficult. The latter objection can be overcome by putting the cocoons on wire gauze in the boiling water so as to keep them always at the right level: the former is actually not valid, as the thread does not end at the mouth, which is closed with loops. The cocoon is, however, different in fundamental structure from other cocoons and we have seen experienced reelers fail to reel it.

With mulberry and tasar cocoons, the thread can be reeled off in a length of 500 to 700 yards, provided the end can be found ; a large part of the cocoon is practically homogeneous, formed of one thread going round and round, and more or less continuous. In eri silk, the cocoon is composed of (1) the cradle, (2) a number of detachable layers, from three to seven, (3) an inner layer where the thread weakens off and is much covered and cemented with gum forming a shiny smooth layer. Instead of being a perfect oval with both ends alike and hard, one end is hard and even, the other is open and loose ; there are also " patches," where a piece woven closely and not in circles round, is detached as a tangle. In actual reeling, the thread comes off for a time, then picks up a number of others or works under a patch and brings it off as a tangle. Actual threads as long as 20 feet can be readily got

off a layer, but sooner or later several threads foul, or a " patch " comes off. We do not believe that reeling, as done usually, is possible for these reasons : the worm does not spin its cocoon as the mulberry worm does ; it makes the cradle ; then it makes layers (usually seven or eight) with rests between ; it spins loops at the mouth, but circles or ovals at the closed end ; it strengthens spots of the cocoon with discontinuous patches. It is, of course, impossible to see what goes on in the cocoon after a certain point, but from an examination of very many cocoons treated in different ways, we do not believe that, in the ordinary way, the cocoons can be reeled. Whether a system of reeling can be devised by experts in reeling remains to be seen, but we believe that reeling, as now practised, cannot be applied to this cocoon, whether to cocoons from which the moths have emerged or to cocoons from which the moth has not emerged and in which the chrysalis has been stifled. Nor is it likely that reeling, if possible by experts, could ever be simplified so that it could be done cheaply and with ordinary labour.

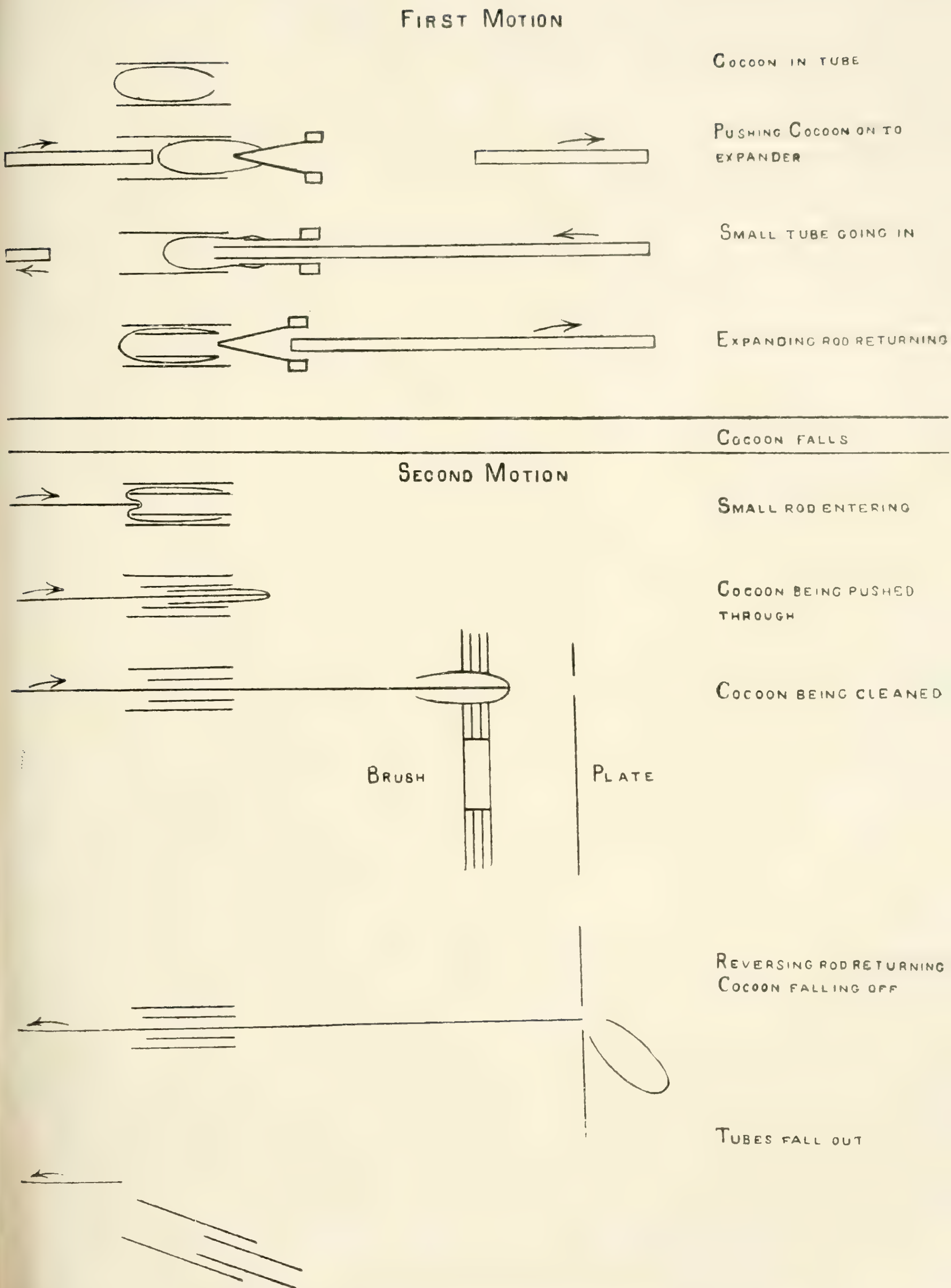
Another factor in reeling is this : in mulberry silk, the gum of the silk is softened in hot water and as the fibre from each cocoon joins the others at the eye, they consolidate into one thread, the gum on the fibre uniting them as it cools and dries. In eri silk, the fibres, after passing through the eye, separate again, the gum not uniting them as in mulberry silk. The physical properties of eri silk are very different from mulberry silk [as also from tasar silk] and the chemical composition of the gum is evidently different, as will be seen when cocoons are boiled.

Cleaning Cocoons.

When the moth emerges from the cocoon, it leaves behind it the empty pupal skin as well as the old dried caterpillar skin. If the cocoons are carded, these remains get broken up, mixed with the silk and have to be removed by special methods. If the cocoons are used for spinning, the spinner must use care to avoid spinning in fragments, must waste the inner layer of the cocoon, and, in

boiling the cocoons, much dirt comes out in the water and stains the cocoons. It is in every way desirable to clean the cocoons and a process for doing so has been discovered.

If an unboiled cocoon is taken in the fingers and a tapering piece of wood, such as the handle of a long penholder is pressed against the closed end, the closed end may be pushed through the open end and the cocoon turned inside out. In so doing all the dirt is pushed out and a perfectly clean cocoon obtained. This is the principle employed in this process; the principle and machines for doing it have been patented by the inventor, Mr. R. W. Coryton. If the work is done by hand as described, it is excessively tedious and slow. The machines are the only successful method of doing it. There are two machines, a simple hand one and a more complex hand or power one. The working of the latter machine is this: each cocoon is placed in a brass tube, after its mouth has been slightly opened. The tubes are placed on an inclined shoot on the machine with the open end of the cocoon to the right. They slide down one by one as the machine works; each cartridge comes opposite a hole at the left side of the shoot, through which comes a rod, which pushes the cocoon to the right on to an expander which enters the opening; the expander is then expanded by the pressure of a small brass tube which is forced into it from the right and which passes right into the cocoon: the rod pushing in the small tube pushes it off the expander back into the first tube; we now have the cocoon back with a small tube inside it. The two tubes and cocoon then drop and come opposite another, opening in the shoot, on the left, through which comes a small steel rod, which pushes the closed end of the cocoon into the small tube and turns the cocoon inside out, pushing it right through the small tube, beyond it, through revolving brushes and through a plate, where, as the rod returns, the cocoon falls off into a shoot and comes out of the machine. The rod returns to the left, clear of the cartridges which fall through into another shoot. Meanwhile another cocoon has come down above and been provided with its inner tube. At each cycle one cocoon gets its tube, another gets pushed out and so



WORKING DIAGRAM OF CORYTON'S COCOON REVERSING MACHINE (LARGE MODEL).

on. By simply feeding large tubes containing cocoons down one shoot, small empty tubes down another and turning a handle, cleaned cocoons are turned out at the rate of 30 to 60 per minute.

The same inventor has devised a simple apparatus for effecting the same thing in a simpler manner suited to the small grower and requiring no elaborate apparatus. The machine consists of a fixed expander, through which is pushed a brass tube fitted inside with a spring; opposite is a fixed steel rod which strikes against the closed end of the cocoon and reverses it while entering the tube. The spring pushes out the cocoon as the tube is drawn back.

To prevent the cocoon striking on the rod, a swinging fork pushes it off as the tube is drawn back, the fork being weighted below. For this machine, dry, well-opened cocoons are essential. The instructions given below sufficiently explain the machine.

INSTRUCTIONS FOR ERECTING AND WORKING

CORYTON'S PATENT ERI SILK COCOON REVERSER. (FIG. 10.)

MODEL II.

Object of the Machine.

When emerging from the cocoon through the aperture left in it by the caterpillar when spinning, the Eri Silk Moth leaves behind it inside the cocoon the skin of the pupa, also often some excrement and other foreign matter.

If this extraneous matter is not removed prior to boiling the cocoons to degum them, not only is the silk discoloured but the pupal skin, etc., becomes entangled with the silk and causes a considerable quantity of waste when cleaning.

The object of this machine is primarily to reverse the cocoon before it is boiled, and so clean it. In this condition, all foreign matter can be easily freed from the parchment-like skin that forms the inner lining of the cocoon. Secondarily, to afford buyers of cocoons a certainty that they are buying silk and silk only. When a demand for these cocoons arises, growers may try to increase their profits by killing the moths before they emerge and thus increase the weight of the cocoon.

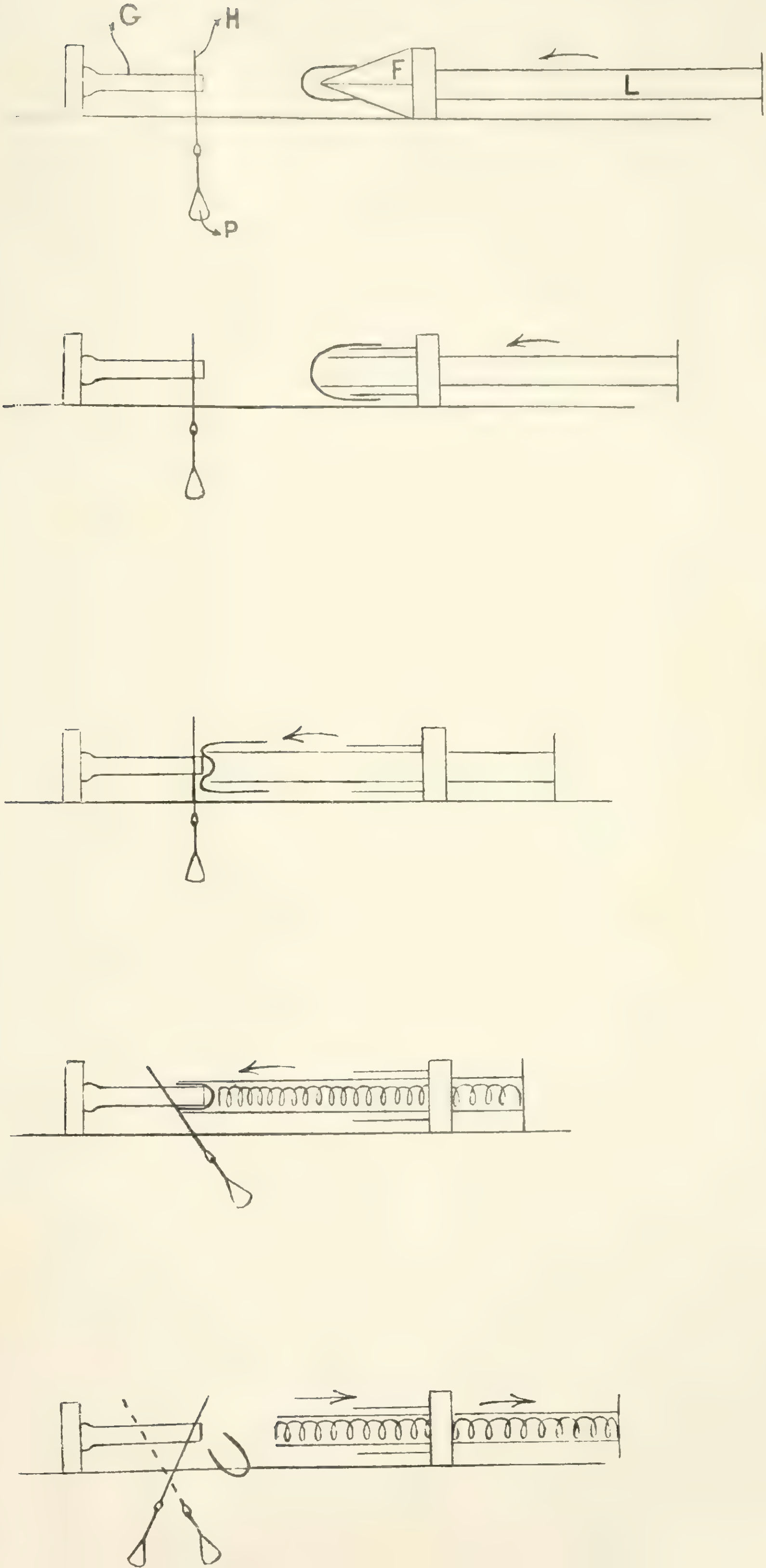
Buyers would do well by themselves to hire these machines out to the native growers and insist on purchasing reversed cocoons only.

To erect the machine.

Take the machine out of the box in which it and a pair of stretchers are packed.

Place the wooden stand " A " so that the slot " B " in the top cross bar " C " is closer to the leg that is further away from where the operator is to sit.

SCALE — 12 INCHES



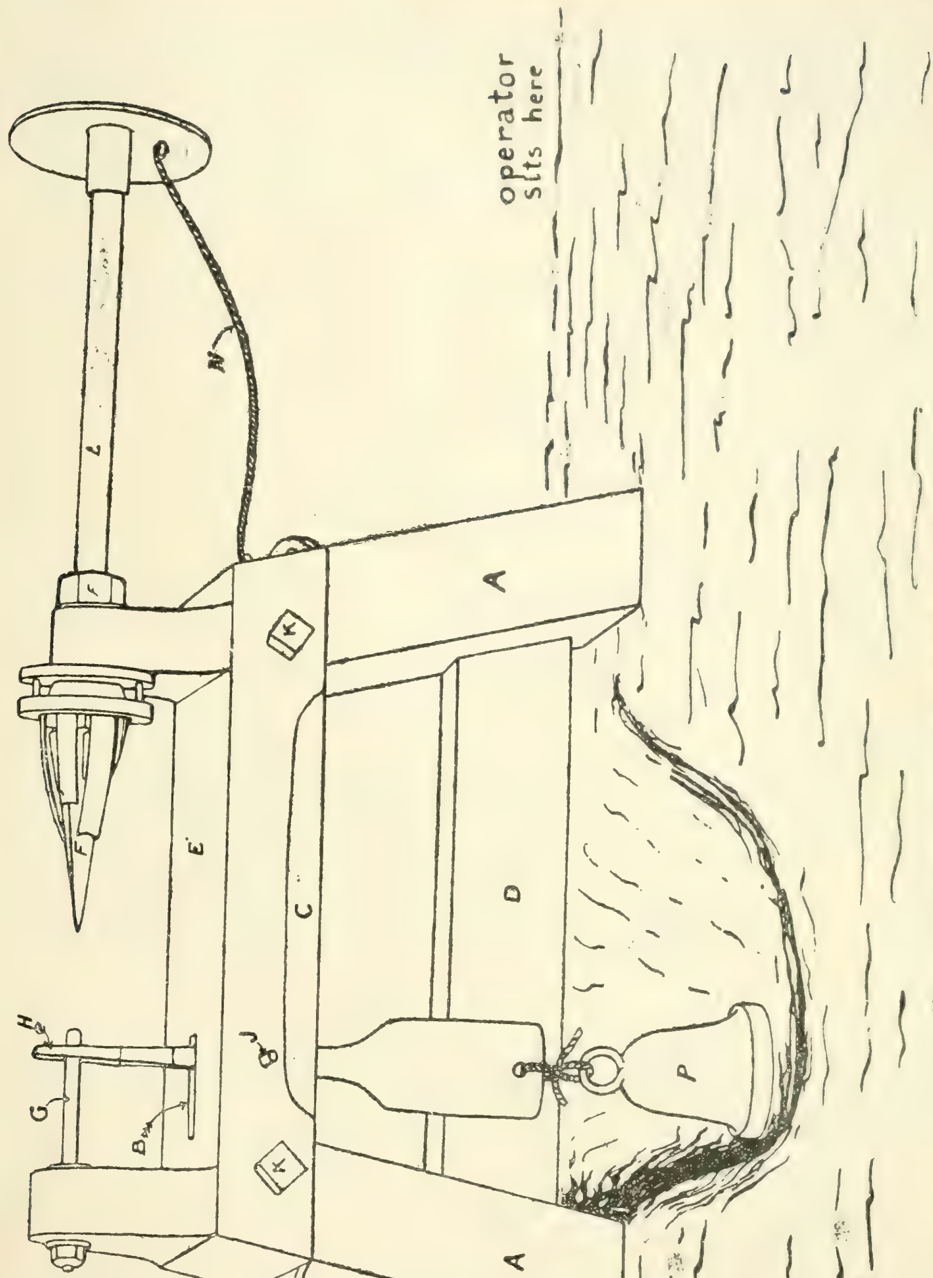


Fig. 10. Coryton Cocoon Reversing Machine.

Bury the legs of the stand so that the lower cross bar " D " is at ground level. Ram earth round the legs to keep the machine firm.

Place the casting " E " on the stand, seeing that the slot in the casting and cross bar of the frame coincide and secure by the bolts K. K. to the stand.

If correctly fixed, the expander " F " will be towards the operator (pointing away from him) and the reversing point " G " further away and pointing towards him.

Pass the forked brass pendulum " H " through the slot, the fork passing on either side of the point " G." Pivot on the pin " J " passed right through the casting and top cross bar.

Hang on the pendulum weight " P." The pendulum should swing freely. Push the brass tube " L " about 2″ into the Expander " F " and adjust the cord " N " to prevent the tube " L " being drawn too far back after each operation.

A *small* amount of oil may be applied to the tube with advantage.

The machine is now ready for use. Two points must be especially noticed before it is attempted to reverse the cocoons.

(*a*) The cocoon must be dry.

(*b*) The cocoons must be pierced and the moth emerged from them.

To operate the machine.

Take the cocoon between the first finger and thumb of both hands and open the passage made by the moth when emerging from the cocoon.

Insert half way down the cocoon the stretchers (sent with every machine)—and open the mouth of the cocoon as much as the stretchers will allow.

Place the cocoon on the points of the expander taking care that the expander is not inserted more than $\frac{2}{3}$rds of the way down the cocoon.

Push home the brass tube by applying pressure on the palm-plate and the cocoon will be pushed off the expanding points and on meeting the reversing pin "G" will disappear up the tube "L." Draw the tube back again to the full extent of the cord and the cocoon, now reversed, will be ejected off the reversing point (Fig. 11).

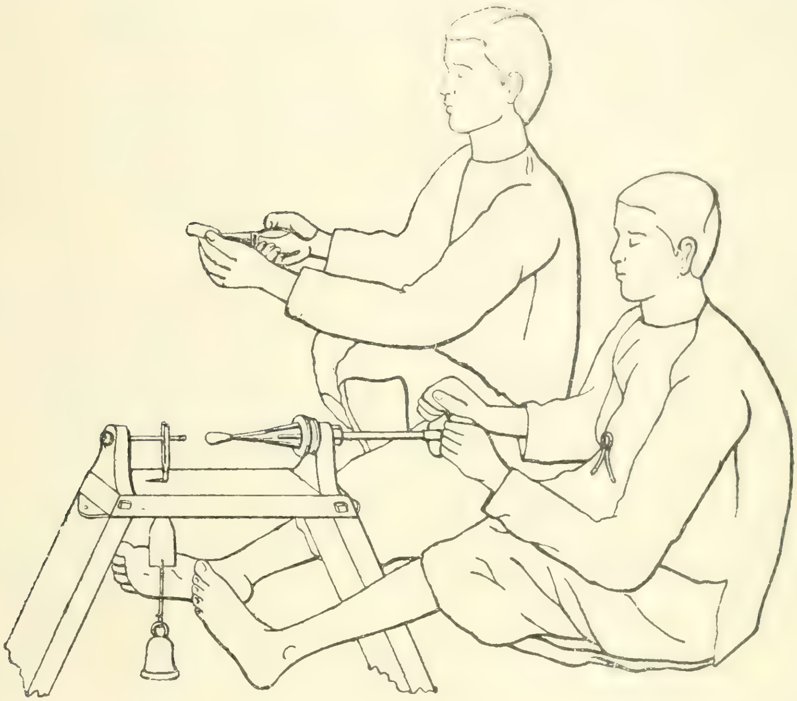


FIG. 11.

Occasionally an extra large cocoon sticks in the tube. A small bit of bamboo the thickness of a lead pencil if inserted in the back of the tube stimulates into action the ejecting spring which is inside the brass tube.

BOILING OFF.

The thread of the cocoon consists of a core of fibroin, and a covering of sericin or gum ; the latter causes the threads to adhere

and to form the close texture of the inner layer of the cocoon. Before spinning the threads, the gum must be dissolved sufficiently to free the threads. This is done by treatment with a weak alkali. The ordinary practice in Assam is to take sufficient water to cover the cocoons, to dissolve in it a weight of castor ash equal to the weight of silk and then to boil till the cocoons are soft throughout. To prevent entanglement of the cocoons they are placed in a cloth, not directly into the liquid. Castor ash was analysed :—

"ASH FOR THE SAPONIFICATION AND CLEANING OF SILK.

Water soluble portion contains practically nothing but a mixture of the Sulphates and Chlorides of Magnesium and Potassium together with 28·3% of Potassium Carbonate. In order to replace its use as a saponifying agent by that of a pure salt, use equivalent proportion of Potassium Carbonate. Since, however, Potassium Carbonate $K_3 CO_2$ is very deliquescent, it will be necessary to first analyse the ordinary commercial Potassium Carbonate before using, then use in the proportion indicated by the above analysis."

A number of experiments were made to determine if ordinary soda (Sodium Carbonate) could not be used, as the crude ash is dirty and impure. The following are results of trials :—

I.	Silk 100 grains. Soda 12½ grains. Water 200 c.c. Boiled for 25 minutes.	Unsatisfactory.
II.	Silk 30 grains. Soda 7½ grains. Water 100 c.c. Boiled for 15 minutes.	Quite satisfactory.
III.	Silk 30 grains. Soda 15 grains. Water 100 c.c. Boiled for 10 minutes.	Not good.
IV.	Silk 30 grains. Soda 30 grains. Water 100 c.c. Boiled for 10 minutes.	Quite satisfactory.
V.	Silk 30 grains. Soda 45 grains. Water 100 c.c. Boiled for 5 minutes.	Not satisfactory.

VI. Half a seer and not more pierced cocoons can be conveniently boiled in a kerosene tin. Half a seer of castor ashes necessary with 2 gallons (*i.e.*, half a tin) of water for this weight of silk. Boiled for from 45 minutes to 1 hour.

$\frac{1}{4}$ pound soda.
2 gallons water.

In this cocoons soaked first and then tied in a piece of cloth (as usual with ashes) and then the cocoons boiled. Some loose cocoons were also boiled along with the bundle to see when the gum of these loose cocoons would be completely dissolved; it was dissolved after full half an hour's boil (compare expt. II). The bundle was boiled for 45 minutes so that the action of the soda would be perfect even on the innermost cocoons in the bundle. This gave a perfectly satisfactory result. This experiment was identically the same as II, but the results were so different on account of the quantity of the cocoon and water.

$\frac{1}{2}$ seer of cocoons.
$\frac{1}{4}$ seer of soda.
2 gallons of water.

In the following experiments, other reagents were used for boiling off, as it was found that the cocoons were whiter if boiled with soap or caustic alkali.

1. *Caustic Soda*, 5%.
   Cocoons 875 grains.
   Caustic soda 44 grains.
   Water $1\frac{1}{4}$ pint.

The soda was dissolved in water and placed on the fire: it boiled in 10 minutes, the cocoons were put in and in 15 minutes the gum was dissolved.

2. *Bar Soap*, $12\frac{1}{2}$%.
   Cocoons 875 grains.
   Soap 110 ,,
   Water $1\frac{1}{2}$ pints.

The soap was cut and boiled until dissolved. The cocoons were put in and boiled for half an hour; the gum was not dissolved and the cocoons were left in for 24 hours, when the gum was dissolved.

3. *Washing Soda*, 25%.
   Cocoons 875 grains.
   Soda 219 ,,
   Water $1\frac{1}{4}$ pint.

The soda was dissolved and boiled; the cocoons were put in and boiled for 15 minutes when they were ready.

4. *Bar Soap*, 25%, *not boiled.*
   Cocoons 875 grains.
   Bar soap 219 ,,
   Water $1\frac{1}{4}$ pints.

The soap was cut up, boiled in the water and dissolved and the solution removed from the fire. The cocoons were put in; some were ready in 6 hours, but after 20 hours most were not ready and required boiling for 15 minutes.

5. *Caustic Soda, 5%, without boiling.*
Cocoons 875 grains.
Caustic soda 44 grains.
Water $1\frac{1}{4}$ pints.

The cocoons were put in the boiling solution after removal from the fire and were ready in 12 hours.

6. *Soda Crystals, 25%, without boiling.*
Cocoons 875 grains.
Soda 219 ..
Water $1\frac{1}{2}$ pints.

The cocoons were put in the boiling solution, removed from the fire, and allowed to stay there 20 hours. They were not ready and required boiling for 20 minutes.

The best method of boiling we believe to be as follows: Soak the cocoons in water for 18 hours, changing the water several times; then boil in Crystal soda, 25% of the weight of the cocoons (2 chittacks to half a seer of cocoons in a kerosene tin) for 45 minutes or 12% of Mono-hydrated soda (1 chittack to $\frac{1}{2}$ seer of cocoons in a kerosene tin); then remove the cocoons and wash; then put into and move about, or boil for a few minutes in a hot soap solution (10% of the weight of the silk). Then wash in running water or several changes. This leaves the cocoons white and clean, in a fit condition to dye or to spin.

In practice we omit the soap as, for ordinary work, we do not require the cocoons to be very white. If it is desired to make them very white, they should be treated with soap and after washing put for a few moments into dilute Sulphuric acid ($\frac{1}{2}$ per cent. in water). This makes the cocoons white and gives the stiff "Scroopy" feeling: if this is not required, wash out the acid and put into dilute soap or soda solution, and then wash well; they will be very white but not "Scroopy." The above processes of washing apply to uncleaned cocoons; if one is working with clean (reversed) cocoons,

one can omit the preliminary soakings and washings, as there is no dirt in the cocoons.

This process of treating cocoons is radically different from that used for mulberry silk and the methods used for mulberry silk do not apply to eri. The greatest difference between mulberry and eri silks, as silks, lies in their composition ; this has not, so far as we are aware, been chemically investigated ; mulberry silk is far more easily divested of its gum, is far less resistant to the action of alkalies and can be treated by a process of maceration, with perhaps a short boiling in soap after. Eri silk cannot be so treated ; we have not been able to treat cocoons by any process of maceration with subsequent boiling in soap ; boiling with soap does free eri silk from gum, but not as well or as quickly as soda does ; in actual practice, eri silk can be boiled with 12% of its weight of monohydrated Sodium carbonate without suffering in strength ; such drastic treatment would not be adopted for mulberry silk, nor is it required. In this respect eri silk is like "wild silks" such as tasar, that is, all the silks in the trade not derived from *Bombyx*.

Carding.

Boiled dry cocoons are very readily carded by hand for hand-spinning if this is required and this effects a separation of the dirt contained in the cocoon from the fibre. The simplest method is simply to take each cocoon in the fingers and with each hand to gently loosen the cocoon till it all comes away as a loose fluffy mass, leaving the very thin inner shell holding the empty chrysalis case and caterpillar skin. There is a small amount of waste, but this can be recovered by fresh boiling. If carding were a necessary preliminary to spinning, it would be worth while devising a hand machine to do it ; but, while carded silk can be spun, especially on the charka, it is not necessary or desirable. In the Punjab, wool is carded and those who do this can also card eri cocoons and then spin a fine even thread just as is done with wool. It may be found desirable to do this where wool-carding and spinning is familiar to the people and

if so, hand-carding is a very light occupation for children which they learn at once. We do not use carded cocoons as a rule.

SPINNING.

There are three methods of hand-spinning in use at present.

(1). The Taku or Spindle (Fig. 12) is a simple spindle with a weighted end ; the spindle is attached to the drawn-out end of the wet cocoon and spun, the thread being drawn out evenly by the fingers till the spindle falls sufficiently when the thread formed is wound off and the spindle again spun to twist a fresh length. It is a slow process, well-known for making "Matka" thread of waste mulberry silk and is the least economical of the methods, though it produces good thread.

FIG. 12.

(2). The "Charka" (Fig. 13) or Spinning Wheel is familiar wherever cotton is spun. It consists of a wheel with a belt which

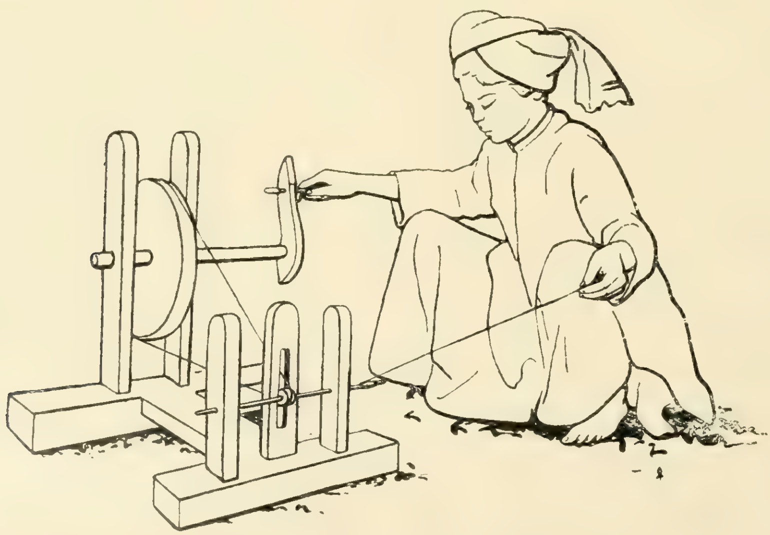
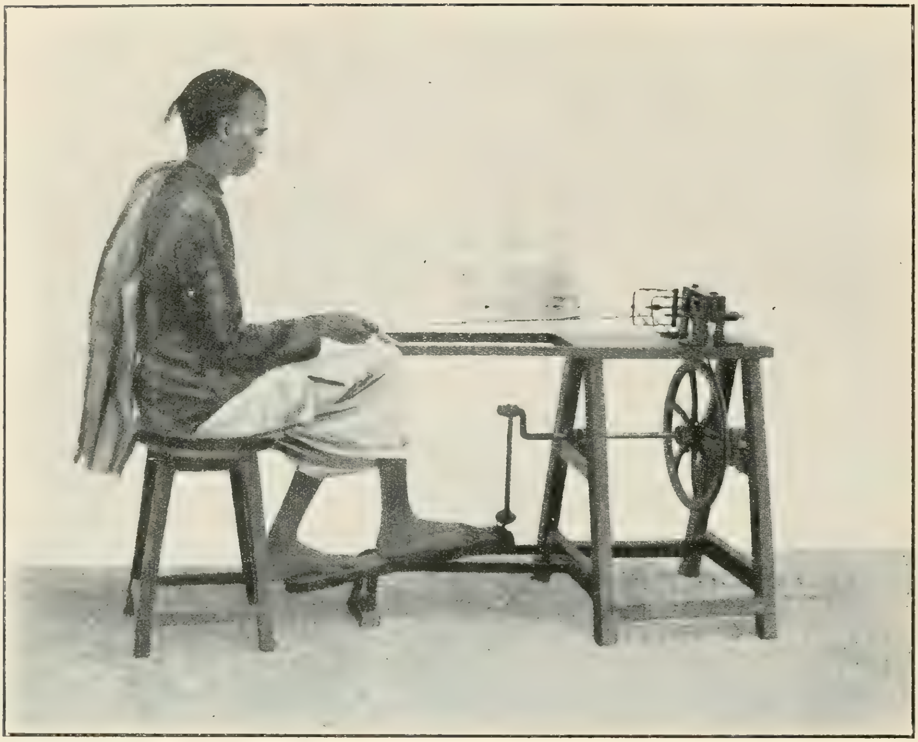
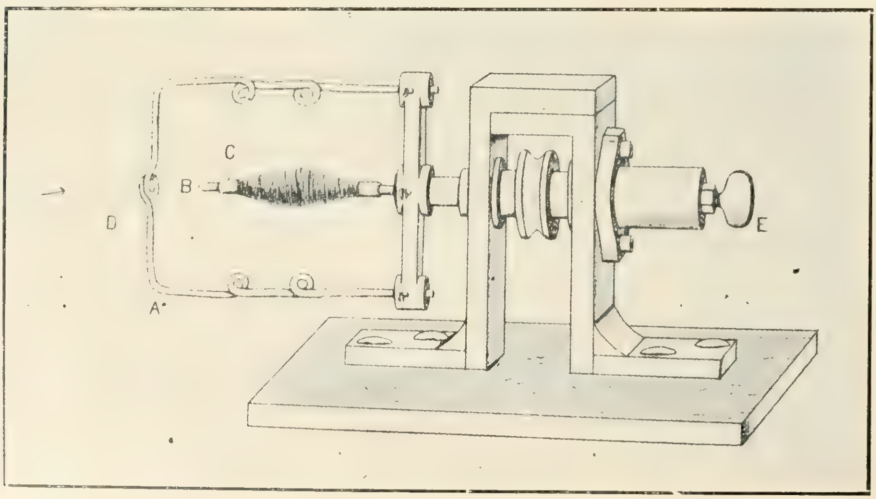


FIG. 13.

PLATE IX.





THE PUSA CONTINUOUS SPINNING MACHINE.

passes round a small pointed spindle set between uprights; the wheel is turned with one hand, causing the pointed spindle to revolve rapidly; if it has been joined to a pulled-out end of the cocoon and the cocoon is pulled away by the left hand, the thread is twisted and drawn out; when the cocoon is held out as far as possible, the thread is disengaged from the point and is wound off upon the base of the spindle, and a fresh length begun. Dry or carded cocoons are done very well upon this machine, which makes very fine thread. The sole disadvantage is that the process is not continuous, as the wheel must be stopped to wind the finished length on to the spindle: only one hand is available for the cocoon, the other being used to turn the wheel. This process is the familiar one in India and it is one of the advantages of the industry that the material can be so readily used in this way in India generally; the people have nothing to learn.

(3). *The Pusa Machine.* An improvement upon the above has been devised, based upon the old "flying needle" principle, so universal in power-spinning of all kinds. The principle of the machine is this: a thread passes to a point revolving round a revolving spindle and from it to the spindle; if the two revolve at the same rate, the thread is only twisted or only wound on the spindle according as they revolve in the same or opposite directions, but if they revolve at different rates, the thread is dragged from the revolving point and wound off upon the spindle; in so doing, the revolutions of the point give the thread twist, and if the fine end of the cocoon is fed in, it becomes thread, as it is drawn off and twisted.

If the two motions are adjusted, one can get in a given length a definite amount of twist; thus if one inch of thread is drawn in while the flying point makes six revolutions, the thread will have six twists in one inch. To secure that, there shall be a difference in the rates of motion of the spindle and the needle can be done in two ways; they may be driven by belts off pulleys of unequal size, or the spindle may be free to revolve and slightly "braked;" if the spindle is free to revolve, the thread drags it round and is not

wound off ; but if the spindle is braked by friction, it turns more slowly than the needle and so pulls off the thread. The details of such a machine will vary, but the principle is the same ; the Pusa Machine consists of a pulley, turned by a treadle and belted to the flying needle ; the needle may actually be a hollow bent needle, or a wire with a loop at the end and other loops on the arms. It revolves round the spindle, which revolves more slowly and the thread is fed in at the base of the needle or through the loop at the end ; the spinner has both hands free to draw out the cocoon into a proper length and feed it continuously to the thread.

The great advantage of the machine is that it brings the fibre off the cocoon in very long individual strands ; it is really a process of very coarse reeling and the " staple " of the fibre is very long. Wet cocoons are used as they give the best results but carded or dry cocoons can also be used. The photograph illustrates the machine best ; there are several available patterns, the best doing two threads at once, not a single one.

In spinning, there is a certain amount of waste but not a very great one. There is of course a very large amount of loss of weight prior to spinning ; thus about 17 per cent. of the cocoon is old pupal and larval remains ; another 8 per cent. boils off as gum ; the average figures for dry empty cocoons are as follows :—

Dry cocoons 100.
Dry cleaned cocoons 78.
Boiled ,, ,, 70.
Thread 65.
One seer of raw cocoons gives 10 to 12 chittacks of thread.

Preparation of Thread.

The thread as prepared by the spinner undergoes no special preparation before it is used for the warp or put in the shuttle except the processes usually adopted by the local weavers with cotton. The warp threads are run off on to big spools, warped, the warp arranged, stretched, sized and brushed ; the weft threads are run off on to small pirns for the shuttles and kept wet till wanted. In

case of extra thick thread being required for a coloured border, two or more threads are twisted together either in the usual way of bobbins on a charka or in whatever way is used locally. For eri fabrics as commonly produced there is no special preparation and in weaving it is treated just as cotton thread is.

Weaving. A Handspun Thread.

The threads produced from the charka, taku or continuous spinning machine are woven in the usual way on the ordinary handlooms of this country. They are not adapted to power looms unless very well spun as they break. In the ordinary process of sizing, warping and weaving, the threads become very dirty, so dirty that the pure white cocoons become " écru " colour, the dirty colour of Assam eri silk. With careful sizing and weaving this may be avoided. We have used various looms and here express no opinion as to which pattern is the best. A loom that weaves cotton will weave spun eri silk and which loom will suit any locality best depends purely on local circumstances. As a rule, eri silk is woven into moderately coarse cloth, either for suits or for use as whole pieces uncut as wrappers, saris, dhotis, etc. These are either natural colour, or cream colour, the latter being obtained by bleaching with sulphur. Into these a coloured warp border may be woven, doubling the thread of the warp at the edge, or a coloured end border, using thicker coloured thread for the weft at each end.

It can be woven into twills, tartans, checks, stripes, etc., by the usual methods, but these can never be as light and thin as are produced from reeled mulberry silk and are not the beautiful fine fabrics produced from such silks. The fineness and gloss of mulberry silk cannot be got ; by fine hand spinning and good weaving one can get a fine cloth, with little gloss, with great softness and extreme durability. With ordinary spinning and weaving, heavier cloth is produced suitable for wearing, for coloured table cloths and curtains, for those fabrics in which strength and durability are required but not the sheen or delicacy of the finest silks. Most silks deteriorate with use ; eri silk improves, since the soft fibre loosens a little, fills

in the fabric between the threads and gains in lustre and softness. The individual threads have great strength, a good twist and no projecting ends of silk, only loops which have great strength and which give the fabric its softness and which fill in the points, making a very soft even surface.

In the ordinary hand-weaving with handspun thread, there is no object in having a fly shuttle loom or an improved pattern of any kind ; the best loom is the ordinary hand-loom in which the shuttle is thrown by hand ; for weaving greater breadths than 36 inches conveniently, we use a fly shuttle loom, the picking done by pulling a cord ; if the shuttle moves rapidly, it is certain to break the warp threads as they are not really even, and it is useless attempting to hurry the weaving if handspun thread is used for the warp. If millspun thread is used for the warp, it will of course pay to instal a really good fast loom of which there are many patterns, the Churchill loom of Ahmednagar being probably the best. There are considerable differences in procedure in weaving fine or coarse cloth and naturally much depends on the evenness of the thread. The best heavy fabrics are made by using for the warp fine thread of which two or more are twisted together. It is easier to make a fine thread even in spinning on the charka than to make a coarse one ; if such fine thread is woven direct, it makes very fine soft fabric, but it requires good careful weaving and is slow to weave. But if two, three or four of such threads are twisted together, the unevennesses average out and one gets very even strong thread, suitable for warp. In making bordered pieces, such thread should be used, as the threads especially must be thick to cover the white in the weft ; also if thick coloured warp is used to make the border, the same thickness must be used in the uncoloured centre or the centre will be very open owing to the close " beating up " of the weft being stopped by the thick border warp threads.

For weaving fine eri cloth from handspun thread, we use a reed of 20 to 22 dents, and this is the best for the cloth required by the Calcutta market ; for coarser thread a reed of 14 to 16 dents may be used.

It must be remembered that eri silk cloth, as usually made from handspun thread, does not shrink, but in time stretches a little ; this must be allowed for and it is one of the peculiarities of this cloth.

B. Millspun Thread.

Eri silk spun like waste mulberry silk is almost indistinguishable from the latter and can be used in the same way. We have used counts 160/2, 160/2, 280/2, but other counts are made.

Finishing.

Ordinary undyed cloth is ' finished ' in a variety of ways, according to the appearance required. Ordinarily, the cloth is washed in hot water with soap and then dried and ironed. This leaves the colour unchanged. To get a whiter colour, the cloth is washed in boiling water and soap, then rinsed, put into water containing a little Sulphuric acid ; from this it is put into water and then again washed with soap or soda. To get a cream colour, the cloth is put into boiling water, then rinsed with Sunlight soap, and then, after rinsing, put into a weak solution of Citric acid or water containing the juice of limes, lemons or other acid fruits. A very good cream colour is also got by bleaching the cloth with Sulphur as described below. There are other methods used in the trade, some of which are secret and with undyed fabrics great importance is attached to proper finishing. A cream colour is generally required in India, as being the proper colour of the best eri silk.

We may draw attention to the very great value of boiling the cloth, in all processes, as this improves it very much. Eri silk improves very much by use and washing ; it is at first rough, coarse and dull-looking ; a great deal of this is removed by boiling the cloth in water with or without soap or soda ; it will not stand boiling with acid. A simple way of getting a good cream colour is to boil the cloth for one or two hours with $\frac{1}{8}$ of its weight of soap (bar soap) and then exposing to the sun for a few days. For ordinary small lots, any good hard soap may be used, but if large lots are to be done, it is best to get a good pure olein bar soap specially made for boiling-off silk.

Bleaching.

Though the cocoons are white at first, the silk becomes dirty in the course of boiling, spinning and weaving till in the usual course the silk produced is écru colour, a colour very suitable for use in this country, but not adapted to dyeing in light shades. Except for very special purposes, the colour does not matter; by exercising great care in boiling the cocoons, by washing them well after boiling or by prolonged soaking in water, by care in the spinning and weaving, a cloth can be got which is, after being washed, nearly white. To get the whitest, one must bleach. Very beautiful white thread can be produced by bleaching with Hydrogen Peroxide: nearly as white thread is produced by "blankit"; but the ordinary process of weaving is sufficient to again dirty the threads, and unless good weaving methods are used, the cloth will not be white. Cloth can be whitened by washing and exposure to sunlight for long periods. Tests have been made of bleaching with Aqua Regia and with Sulphur Dioxide (Sulphurous Acid). We recommend either of the following processes, but would emphasise the fact that such bleaching is not as a rule required. For those who wish to turn out high-class white or delicately dyed fabrics, the processes 1 and 2, though costly, will be of value, applied either to the thread or to the fabric.

(1). *Bleaching thread with "Blankit."*

Boil the silk for one hour in a solution containing ½ lb. Marseilles soap for 5 gallons of water. Wash thoroughly and put the silk for about 12 hours, with an occasional stir, in a solution of about ¼ to ½ lb. "Blankit" per 5 gallons of cold water. Rinse the silk in water which has been acidified by the addition of a little Sulphuric acid, then rinse in fresh water.

(2). *Bleaching thread with Hydrogen Peroxide.*

For 10 lbs. of silk take:

2—3 gallons commercial hydrogen peroxide.

3¼—4½ gills Sodium Silicate.

1—1½ lbs. white soap dissolved in 12 gallons of water.

This is warmed to 120° F. and the silk put in for several hours : at intervals it is wrung out and turned. When bleached, it is placed in water acidified with Sulphuric acid, then rinsed in fresh water. The bleaching liquid is used again, replenished if necessary.

(3). *Bleaching cloth or thread with Sulphur.*

Suspend the material in a closed chamber, after soaking it in soap and water ; then burn sulphur in the chamber completely closed, so that all the oxygen of the air is combined with sulphur ; keep the material in for 12 hours, then remove and wash well. The colour is not quite white, but rather cream colour.

Dyeing.

Eri silk, as other silks, is readily dyed with a large range of colours. The dyes may be classed as :

(1). "Natural" dyes obtainable from indigenous plants and used with mordants.

(2). Anthracene or Alizarin dyes, which are similar to the plant dye Madder but are made artificially and require mordants.

(3). Aniline colouring matters, which are applied direct, with acid or other agents, or which are "developed."

In the first and third classes there are dyes which are fast to light or to soap, or to boiling water, or which are fugitive to light or will not stand soap or boiling water. There is no inherent superiority in plant dyes over any others : some are fast to light, some fade very rapidly ; but they were formerly obtainable in this country, their use was in many cases well known and, when properly applied, they give a good range and depth of colour. The prejudice in favour of these dyes is due to the fact that many aniline colours are sold and used which are not fast to light and it is rather the abuse of these dyes which has led to the general feeling that "natural" dyes are preferable to "synthetic" ones. Provided only fast aniline dyes are utilised, there is no objection to them and they have great advantages in ease of application, range of colour and delicacy of tint. The dyeing of silk is in many respects similar to that of wool, as opposed to the dyeing of

cotton; Watson has shown that silk is a better material with which to use indigenous natural dyes than is cotton, and silk is also a particularly good material with which to dye with many of the aniline colours. Some dyes require mordants, *i.e.*, the use of some substance to enable the colour to develop on the material, alum being a common one used. Indigo requires special treatment, since it is not soluble in water, and a soluble compound has to be produced, with which the silk is impregnated, and which on exposure to the air oxidises to indigo and is fixed upon the fibre. Aniline dyes (with few exceptions) require no mordant; some are applied with the addition of "boiled off liquor," *i.e.*, the liquid in which cocoons have been boiled to dissolve the gum, either a gum-soap solution or a solution of soda-gum or potash-gum, all of which act as an alkaline bath: this dye-bath usually requires the addition of either acetic acid, or sulphuric acid according to the dye used and the shade required; not more than 15 to 20 per cent. of "boiled off liquor" containing soap should be added or ten per cent. of liquor made with soda and its function apparently is to make the dyeing more even by making it slower.

The dyeing of eri silk is the same as that of other silks, *e.g.*, mulberry silk, and, since the fibre is white, the bleaching required for tasar silk is not needed. In fact, eri being itself pure white, takes dyes better than other silks if properly handled and kept clean. We have used the same methods for eri silk that are used for mulberry silk and there is no marked difference between the two in their behaviour towards dyes.

Method of dyeing.

There are three methods of dyeing, useful for different purposes. The cocoon may be dyed, the thread, or the piece of cloth. The last admits only of one colour, unless special methods of printing are used or unless the cloth is a mixture of cotton and silk or wool and silk. If it is desired to produce stripes, borders, checks, etc., with two or more colours, then the cocoon or thread must be

dyed. The dyeing of the cocoon must follow the boiling or the dye will not penetrate, and it is less economical than the dyeing of the thread. The cocoons should be carefully boiled in a cloth, well washed so as not to become entangled, and dyed at once in the cloth : if they are put into the liquid direct they get entangled and loose, making the spinning less easy. Cocoon dyeing with aniline dyes is rarely useful ; the dye fastens on the outside of the cocoon too much and the dyeing is uneven. With Alizarin or other mordanted dyes, this is not so marked as the mordant penetrates readily and the dye is more evenly developed through the cocoon. We do not recommend or use the practice of dyeing the cocoon. The arrangements for dyeing in this country are usually simple, and only small quantities are dyed at one time : no machinery is used and for our present purpose, the usual methods suffice. One must have a good water-supply, vessels that can be heated, measures for acids, etc., scales to weigh the silk, dye-stuff, etc.

Natural Dyes.

During the last fifty years, there has been a considerable amount published as to the dyes indigenous to India. To anyone who studies these it will be clear that the use of indigenous dyes varies much from place to place in the details of the processes used, but that there are certain principles underlying it which may not be known to the dyers but which are met by the many curious ingredients used in dye baths. It is useless to go into these and we give here a short summary of the more important dyes used, with the essential features of the processes. Whether alkali, for instance, is obtained from the ashes of one plant or another, or from earthy mineral alkali or from more or less pure alkali purchased in the bazaar, is a matter of local practice ; so with the use of lime-juice, tamarind or acids produced by fermentation. In many cases, it is known that the water of particular wells or rivers is useful in dyeing ; this is probably due to the presence of small quantities of either weak alkalies such as Sodium Carbonate or of such compounds as Glauber's salt

(Sodium Sulphate). We are not aware that the ingredients of such water have ever been investigated.

For dyeing eri silk, we would draw attention to lac-dye particularly. Lac-dye is extremely cheap, obtainable in more or less constant form and gives a very good fast colour. Indigo is also of special value. Beyond these, we do not think that there is any special value in indigenous dyes unless one can secure the very best professional dyers in a locality where dye-stuffs abound. As we are advocating the cultivation of this silk in the cultivated densely-populated areas and not in the jungles or hill-tracts, we do not attribute much importance to natural dyes, with the exception of the two mentioned. Great efforts were made in the past to stimulate the use of natural dyes ; that was done to meet the growing competition of aniline and other synthetic dyes ; since then, the former have been largely ousted, fewer people know the use of indigenous dyes, the dye-stuffs are not obtainable readily or in a pure form, and only in favoured localities, where dyeing still lingers as an indigenous industry, will the dyers be found who can get really good results with plant dyes. The synthetic dyes have also been greatly improved, and there is no reason why the softest and most beautiful tints should not be obtained with the exercise of far less skill and labour and at a smaller cost than was possible twenty years ago with aniline dyes or is now with plant dyes. Unfortunately, dyers use crude colours when they use anilines, and the soft tones of the plant dyes are not so often seen, but this need not be and it would be easier to teach dyers to obtain soft tones with anilines than to revive the general use of plant dyes. Where plant dyes can be got which are really fast and whose use is understood, they should be used ; but we do not believe this can be said of any part of India but the forest or hill-tracts, save with such dyes as cochineal, lac, indigo, kamala, jackwood or myrabolans.

(1). Sapan Wood or Bakam. *Cæsalpinia sappan.*

An infusion of the wood yields a polygenetic colouring matter which with alum gives crimson, with tin salts a brighter crimson, with chromates a brown or purple, with copper sulphate a

claret brown, with iron sulphate a slate or claret colour. It is used to produce crimson. The colours are moderately fast.

(2). Kusum—Safflower. *Carthamus tinctorius.*

An infusion of the petals yields a yellow dye, not used; adding alkali produces a soluble "direct" dye which yields fugitive pinks or reds. It is used chiefly for cotton, and it is said that it was formerly exclusively used for Government red tape.

(3). Kamala. *Mallotus philippinensis.*

The dried powder in the seed capsules yields a red or yellow dye, soluble in alkalies and used with alum as a mordant. It is not fast, though widely used.

(4). Al. *Morinda tinctoria.*

The roots or root-bark yield a red dye, applied with Tannin or alum mordants to material usually steeped in castor oil emulsion. The colours are fast.

(5). Singrahar. *Nyctanthes arbor-tristis.*

The dried corolla-tubes yield a "direct" dye on infusion which dyes an orange colour.

(6). Manjista—Madder. *Rubia cordifolia.*

The infusion gives the same range of colours with mordants as is given by Alizarin, which is its artificially-made form. The dye-stuff is extracted from the dry roots.

(7). Lac-dye.

A colouring matter extracted from the body of the lac-insect (*Tachardia lacca, T. albizziæ, T. fici, T. decorella,* etc.) in the process of shellac manufacture by washing crude scraped lac in water (with or without soda) and precipitating the dye with lime or tin salts. The cloth is mordanted with alum or tin, and in some cases acids are added to the dye-bath. The colour produced is a deep or bright red, fast to light, washing, soap and alkalies. It is a specially good dye for silk, deserving of a much more extensive use. Mordanting with tin or alum, and using the dye with acid gives a

bright red, with alkali, a reddish purple ; mordanting with iron and dyeing with alkali gives a grey. The red obtained with acids becomes purple-red if the material is washed directly in soap or alkali.

(8). Kanthal—Jakwood. *Artocarpus integrifolia.*

An infusion of the heart-wood yields a yellow colour which is fixed on cloth mordanted with alum and is fast to light, etc. It is stated to be much used in Burma.

(9). Annatto—Latkan. *Bixa orellana.*

The dried pulp of the seeds yields a bright orange dye, soluble in alkalis, applied to silk mordanted with alum. The colour is not fast to light.

(10). Dhak—Palas. *Butea frondosa.*

A decoction of the petals yields a yellow dye, fixed on alum-mordanted cloth, which is fast.

(11). Haldi—Turmeric. *Curcuma longa.*

An infusion of the rhizomes yields a yellow dye, which, with acid, is fixed on alum-mordanted cloth. Tin mordants make the colour orange. The colour is fugitive.

12. Indigo—Nil. *Indigofera* spp.

The leaves yield indigo-white, soluble, which on oxidation becomes indigo-blue. The dry powder is reduced, the fibre soaked in it and allowed to oxidise in the air. The blue colours yielded are fast to light, etc. Reduction is effected, on cotton or wool, with :

(*a*). Ferrous Sulphate and lime.
(*b*). Sodium Hydrosulphite and zinc dust.
(*c*). A woad, bran, madder and lime vat (fermentation vat).
(4). A potash, bran and madder vat (fermentation vat).
(5). A soda fermentation vat.
(6). A urine fermentation vat.

A method of dyeing eri silk is given below. (Reduced dyes.)

(13). Myrabolans. *Terminalia chebula*, etc.

Myrabolans, and other plant tissues which yield tannin (babul pods, galls, divi-divi, etc.) will on infusion yield a solution which on cloth mordanted with Ferrous Sulphate gives a durable black.

14. Cochineal. *Coccus cacti.*

Dried Cochineal insects ("German Grains") are extensively used for the very best silk dyeing in some parts of Bombay; the dye is made by pounding three parts of Cochineal and one part of Pista-ful (galls of *Pistachia vera*) and dyeing in the decoction. The red so extensively used for turbans in Western India is thus obtained. The dye is extremely fast to light, washing, perspiration, etc. It is now mainly produced from imported Cochineal, but the Indian Cochineal (*Coccus indicus*) grown in India on prickly pear has been used.

The above colours are combined to give shades and tints; *e.g.*, green is obtained from indigo and turmeric, violet from tannin iron and lac-dye, etc. It is in these combinations that the indigenous dyes are used in so complex a manner. The real art of indigenous dyeing lies in the use of these dyes in combination in a most complex manner, of which no one really good account exists. The practices of the best native dyers have never been really reduced to prescriptions on paper.

Reduced Dyes.

There are two dye-stuffs which require to be reduced in order to be obtained in a soluble form, the colour developing as the reduced (uncoloured) compound is oxidised in air on the fibre. These dye-stuffs are indigo, natural or synthetic, producing blues, and Helindon red, a synthetic dye, giving a peculiar lilac tint. Indigo is used in India for dyeing silk, in a variety of ways, just as it is used for dyeing other fibres, but we give a process for dyeing in detail because we have found that dyers accustomed to dyeing cotton or wool with indigo cannot in all cases do so in eri silk also. We are indebted for this process to R. V. Briggs, Esq., Calcutta.

INDIGO.

Strong Vat.

100 gallons	.. Water	.. ..	.. 500 litres.
2 lbs.	.. Average Indigo.	..	.. 1,000 grs.
2 lbs.	.. Slaked lime (shell)	..	.. 1,000 ,,
$\frac{2}{3}$-1 lb.	.. Zinc Dust (good quality)	..	.. 300-450 grs.
$\frac{2}{3}$ gallon	.. Bisulphite of Soda. 57°T.	..	.. 3,500 c.c.

Medium.

$1\frac{1}{4}$ lb.	.. Average Indigo	.. ..	.. 550 grs.
$1\frac{1}{4}$ lb.	.. Lime	.. ..	.. 550 ,,
$\frac{1}{2}$ lb.	.. Zinc Dust	.. ..	.. 225 ,,
$3\frac{1}{2}$ pints	.. Bisulphite of Soda. 57°T.	..	.. 2,200 c.c.

Weak.

$\frac{1}{2}$ lb.	.. Average Indigo	.. ..	.. 250 grs.
$\frac{1}{2}$ lb.	.. Lime	.. ..	.. 250 grs.
4 oz.	.. Zinc Dust	.. ..	.. 113 grs.
$1\frac{1}{2}$ pint	.. Bisulphite of Soda. 57°T.	..	.. 900 c.c.

Grind the Indigo to an impalpable paste with a little water, add the lime and add to about $\frac{1}{2}$ gallon to 1 gallon hot water (160°F.). Add the zinc dust to the Bisulphite and stir occasionally; let stand till no more smell of sulphurous aid is noticed (about $\frac{1}{4}$ hour). If after $\frac{1}{4}$ hour it still smells of sulphurous acid, add a little more zinc, as it shows the zinc is poor. Then add the Zinc-Bisulphite to the indigo, lime and water and stir. In about $\frac{1}{2}$ hour to $\frac{3}{4}$, the colour will have become yellow. This is stock solution.

Heat the vat and water up to about 120°F. and add to it $\frac{1}{2}$ pint bisulphite previously mixed with zinc. Then add the indigo stock solution, stir well, allow to stand and the vat is ready for dyeing. Wet the material with water, and wring it out; then put it in the vat and after ten to twenty minutes remove it, wring it out and let it oxidise for twenty minutes to half an hour. The number and duration of dippings must depend on the shade required. When this is obtained, wash the material in water and then in a dilute solution of Acetic Acid (1 in 500): then rinse and dry.

After several dyeings the vat will require "sharpening," *i.e.*, bringing into solution the oxidised indigo. This is done by adding one to two pints of Bisulphite reduced with zinc and $\frac{1}{4}$ to $\frac{1}{2}$ pint of milk of lime (20 lime in 100 water).

Yarn should be hung in the vat and turned occasionally, loose silk or cocoons in a net and the bottom of the vat should not be disturbed so as not to raise the sediment.

Helindon Red.

This is an example of a large class of dye-stuffs now being increasingly used which are extremely good but costly and difficult to use. Two parts of Helindon Red powder are mixed with twenty of water and three of soda lye (77° Tw.), and two parts of Hydrosulphite concentrated powder. The whole is kept at 120°F. well stirred till it becomes yellowish ; then add it to the dye-bath, and dip the silk into it lukewarm. Keep it in twenty minutes, wring out and let the dye oxidize in the air. The depth of shade is regulated by the number of dippings. (M.L.B.)

Anthracene (Alizarin) Dyes.

Alizarin is the colouring principle of the madder root and, while it does not itself dye fibres, with different mordants it yields a variety of colours which are extremely fast to light, soap, etc. There are several chemical compounds, allied to Alizarin and produced synthetically from Anthracene, which are commonly termed Alizarin colouring matters. These are obtained from firms manufacturing these dyes who give instructions for their use and prepare them for each tint required. We include in this class Cœrulein, Gallein and allied dye-stuffs which require mordants.

The Badische Anilin and Soda-Fabrik issue a shade card of forty tints produced by these dyes with alum, chrome-alum or chloride of chrome, mordant. Using Alum, Soda and Bicarbonate of Soda (all readily obtainable), the procedure is as follows :—

Put the silk over-night into 60 pts. alum } Per 1,000
6 ,, soda crystals } parts water,

squeeze, wash well in water and pass for $\frac{1}{4}$ hour through Bicarbonate of Soda (·5 per cent. in water), wash. Dissolve the dye in water, add one part of Acetic Acid per 1,000 parts of water, and

wash the silk in this cold bath for $\frac{1}{4}$ hour ; heat to boiling in $\frac{3}{4}$ hour. Wash, soap and brighten with Acetic Acid.

With this method alone, a range of colours is obtained including scarlet, crimson, orange, yellow-green, salmon-pink and three shades of purple. To obtain other shades, one must use Chromium Chloride mordant ; put the silk into Chloride of Chrome 20° Be. for 4—6 hours, wring out and wash well in running water. Pass for $\frac{1}{4}$ hour through a bath containing 5 parts per 1,000 of Bicarbonate of Soda, wash well and dye with Acetic Acid (1 part per 1,000 parts of water) as with alum above. (B.A.S.F.) Alizarin dyes are not usually sold in this country and can be imported in 28 lb. bags. Other Alizarin dyes are dealt with as follows :—

Dissolve 6 parts of alum or Sulphate of Alumina in 10 parts of water and precipitate the solution with 4 parts of Sugar of Lead and 2 parts of Nitrate of Lead previously dissolved in water. Let the precipitate settle, draw off the liquor, dilute to the proper degree. Mordant in this as above, then dye as above ; Alizarin Orange N. paste gives an orange, Cœrulein paste an Olive green, Alizarin Red No. 588 and Alizarin Red P. S. two shades of red (M. L. B.)

Alizarin can be purchased in India in lump form at 10%, 20%, 40%. With this several shades can be obtained with various mordants. Short directions are given for the production of these shades, and we may add that the colour produced with Bichromate and Sulphuric Acid is an extremely good grounding colour for obtaining browns, purples, etc., by dyeing with acid dyes after the Alizarin. It is also an excellent colour by itself. For Alizarin 40%—

1. Claret Red :

   Mordant with 6—10% Alum Sulphate.
   5—8% Cream of Tartar.

   Put in cold and raise to boiling.

   Wash and dye in 5% Alizarin and 4—6% Acetate of Lime or Air-slaked Lime.

   Wash in cold, then raise to boiling.

2. Orange Red :

Add 1—4% Stannous Chloride and 1—4% more Tartar to above Mordant-bath.

3. Orange :

Mordant in 5—8% Stannous Chloride and 5—8% Cream of Tartar.

Dye with 5% Alizarin without Lime.

Adding 4—5% Acetate of Lime makes the colour more red.

4. Claret-brown :

Mordant with 3% Potassium Bichromate.
1% Sulphuric Acid (168° Tw.).

Adding Calcium Acetate to dye-bath makes colour more blue.

5. Blue :

Mordant with 4—8% Ferrous Sulphate.
4—8% Cream of Tartar.

Dye with 5% Calcium Carbonate and 5% Alizarin.

With the exception of the reduced dyes, and of such natural dyes as lac-dye, there are practically no dyes to equal the above in fastness to light, to water, to washing, to alkali (street dust), to acids (perspiration or fruit juice) or to all forms of treatment. They are incomparably the best but their use is difficult. For dyeing thread or cocoons for putting into borders for dhotis, for dyeing any form of cloth that is to be worn out of doors, these dyes should be used exclusively if possible, as they are used at present in this country for Turkey Red dyeing on cotton.

Aniline Colours.

There are a very large number of these compounds used in dyeing; many are used in silk-dyeing because of their ease of application and because delicate fabrics do not last so long that the fastness of the dye matters. We have endeavoured to eliminate the most fugitive dyes, but it must be remembered that a dye fast

to light may not be fast to boiling water or to soap. This is often immaterial as curtains, for instance, would not be cleaned in boiling water but in tepid water and soap, so that for curtains a colour fast to light and to soap would be required.

Another point to consider is whether thread dyed with a colour will, when woven say with a stripe of another colour next, stain the neighbouring material on being washed. Some dyes "bleed," *i.e.*, come off to some extent with soap and dye the fabric; this is a defect which must be taken into account when dyeing cocoons or yarn to be used with other colours. Other points are the fastness of the colour to acids (*e.g.*, fruit juice) or to alkalies (*e.g.*, street dust). In ordinary practice with handloom and simple dyeing methods, there is a danger that coloured warp threads, in the process of sizing, will bleed into white or other colours in the warp. To avoid this occurring, dyed material should after dyeing be placed in a solution of Tannin (8%) obtained by infusing myrabolans 24% or babul pods in water and then in a bath of 4% Tartar Emetic; or the dyed material should after brightening be washed with soap or well washed and wrung in a soap solution. Soap removes the superficial dye that, in sizing, bleeds on to the sizing brush and so on to white or other threads. We have found the Tannin treatment extremely successful with such dyes as brilliant orange, which bleed very much and Tannin is so easily obtained in this country that this treatment should be followed.

No attempt is made here to class the colours in groups according to chemical composition and we have not attempted to deal exhaustively with them. Starting with the ordinary silk dyes of commerce, we have tested and eliminated many and here mention such as we believe to be good dyes giving a large range of shades, so that the dyer may have a considerable choice without having to resort to dyes of whose fastness he knows nothing. The number of dyes is large, the number of names they pass under is much larger but those mentioned below are satisfactory and have been tested. We have not attempted to deal exhaustively or even

completely with the whole subject, only to find a sufficient range of really good dyes.

The Aniline Dyes are grouped as follows:—

(1). Acid Dyes, requiring an acid bath for fixation.

(2). Mordant Dyes.

(3). Basic Dyes, requiring a neutral or weakly acid bath.

(4). Dyes of the Eosine Group or Weakly Acid Dyes (omitted here).

(5). Substantive or Direct Dyes, which dye cotton direct and are used for silk with Glauber's salt or acid bath.

(6). Diazotised or Developed Dyes, which are substantive dyes fixed and developed on the fibre by diazotising.

(7). Dyes soluble in Spirit or Acetine, not soluble in water (omitted here).

Acid Dye-Stuffs.

These dye-stuffs are used with a sufficient quantity of acid not only to neutralise the boiled-off-liquor, if such is used, but to make the bath distinctly acid. Either Acetic or Sulphuric Acid is used or both.

For 5 lbs. of silk, add one gallon of boiled-off-liquor (soap solution) and 1 lb. of Acetic or ½ lb. of Sulphuric Acid to 20 gallons of water, warm; put in the silk, turn and wash it and wring it out; add the dye-stuff dissolved in water, taking say ½ or 1 per cent. at first only. Put in the silk again, turn and work and wring out; heat the bath to nearly boiling, put in the silk, and work it for half an hour, adding more dye-stuff if required. When done, put the silk into cold water, acidified with Acetic or Sulphuric Acid and then wash well. For some dyes, "break" the boiled-off-liquor with Acetic Acid till it is sour, then add it to the dye-bath and add enough Sulphuric Acid to make the bath really acid. For others, no boiled-off-liquor but add enough Acetic Acid to the plain bath to make it acid and dye in that. (Orange II, Fast Red, Flavazine, etc.). Acid dyes are suitable for silk in many

cases owing to their level dyeing, ease of application and beautiful tints; they are far faster than basic dyes, and only inferior to the Alizarin or developed dyes; in many cases they bleed into white fabric or are washed out in boiling water or soap.

As a rule from one to three per cent. of the weight of the silk gives a full shade, and if the dyeing is finished at a sufficiently high temperature in the presence of enough acid, the dye should all be fixed on the fibre, the bath should be clear and exhausted and, on washing the dyed material, the dye should not wash out. If insufficient acid is present, the dye is not fixed, it comes off on the fingers, it washes off in cold water and the fibre is not dyed but simply stained. Equally if the temperature is not high enough at the end, the dyeing will be uneven. We recommend the novice to begin by using small percentages of dye and adding more dye solution to the bath till the tint is right, removing the silk every time the bath is heated up or the dye-solution added. The greatest possible care must be taken in washing out the acid from the dyed silk in plenty of water. When dyeing in a simple manner without washing appliances, one tends to do the washing-out of the acid too rapidly or in insufficient water, with the result that the acid concentrates by evaporation, is held by the fibre and destroys it. Dyed cocoons or thread should be very thoroughly washed out in running water or many changes of water.

2. Mordant Dyes.

For khaki shades and some other very fast ones, the mordant dyes used for wool should be employed, as they are extremely fast and very easy to work. A simple method is to use the Metachrome mordant with the dye and boil all together for two hours.

For an average shade of khaki we weigh out the following, based on the weight of silk to be dyed:

Metachrome Mordant 3%.
,, Brown 1%.
Cyprus Green 0·05%.

The water is boiled with the cloth and mordant; the cloth is then removed, the dyes in solution put in and the cloth replaced; the whole is then kept at the boil till the dye-bath loses nearly all its colour (about one hour) and then for one hour longer to thoroughly fix the dye.

3. Basic Dyes.

For 5 lbs. silk, dissolve the dye-stuff in 20 gallons of water, add 9 to 10 oz. of Acetic Acid (9° Tw.) heat to 140° F. and dye in this bath for half an hour, or, if boiled-off-liquor is used, add enough Acetic Acid to make the liquor sour and then dye. A large number of dyes are included herein which are often fast to washing but usually not to light. These dyes can also be made faster to water by passing into a bath containing 8% of Tannic Acid (24% Myrabolans), if necessary fixing after in another bath of Tartar Emetic (4%). Basic dyes are largely sold and used in India, because no acid or other assistants are required; a simple solution in water is enough to dye silk in many cases, though the colours are not fast. For the Alkali blues there is a special process :—

Dissolve the dye in water and add 4% of Borax; heat to 112°F., put in the silk and heat rapidly to nearly boiling and keep for $\frac{1}{2}$ hour. Take out the silk, wash it, and put into a bath of water containing 5% of Sulphuric Acid. The acid precipitates the colour on the silk, which is then dyed. The Alkali blues are used especially for light blue shades.

Another process is to dye them in a boiling bath containing simply boiled-off-liquor, or a little Alkali, such as soda crystals, such a bath being slightly alkaline and not neutral. It is used for some blues. In place of Alkali, Marseilles Soap is used ($\frac{1}{2}$ oz. per gallon of water) as below for Nitrosamine Red in paste.

4. Substantive or Direct Dyes.

For 5 lbs. of silk, take 20 gallons of water, dissolve in it the dye-stuff, add $\frac{1}{2}$ lb. of Glauber's salt and dye for $\frac{1}{2}$ hour at the boil after adding a little Acetic Acid, or dye in a bath containing boiled-

off-liquor, broken with Acetic Acid. When dyed, place the silk in a fresh cold bath of water containing $\frac{1}{2}$ lb. of Acetic Acid in 45 gallons and dry without rinsing.

For Nitrosamine Red in paste. For 10 lbs. of silk, take 1 lb. of Marseilles soap, $2\frac{1}{2}$ lbs. Nitrosamine paste, 45 gallons water; dissolve the paste and soap in the cold water, put in the silk, heat slowly to boiling and boil for $\frac{1}{2}$ hour without bubbling; wring out the silk, and brighten in a bath of hot water 45 gallons containing 1 lb. of Sulphuric Acid. It gives a yellow tending to orange.

For the Chicago Blues (B. A. Co.) the following process is used: Dye as above; rinse and put the silk for 20 minutes into a fresh boiling-hot bath of 1 to 3% Bluestone and $\frac{1}{2}$ to 1% Acetic Acid 30% in sufficient water. (These percentages are calculated on the weight of the silk as usual.)

5. Developed Dyes.

First dye the silk with a direct (substantive) dye as above. Then prepare a diazotising bath as follows: in 150 gallons of water dissolve 2 lbs. 11 oz. of Nitrate of Soda and to this add slowly 5 lbs. of Sulphuric Acid (strongest). The silk is put into this bath for $\frac{1}{4}$ of an hour, quickly rinsed in cold water and placed in the following developing bath:—

On 1 lb. of Beta-Naphthol pour one lb. of soda lye (75° Tw.), and while stirring very well add five gallons of hot water and then sufficient cold water to make up to 550 gallons.

In this bath it is washed for $\frac{1}{4}$ hour, then rinsed and dried. If one wishes to develop with soap, put the silk after the first bath into a warm soap bath (2 lbs. per 20 lbs. of silk), turn a few times and wash. The bath should be 120° F.

Sulphine (Primuline) diazotised and developed with soap gives a yellow (old-gold shade), with Beta-Naphthol a crimson, with Oxamine developer a deep red; Oxamine blue with Beta-Naphthol gives a deep blue, with Oxamine developers violets, as does also Oxamine Violet. (B.A.S.F.) With Beta-Naphthol, Zambesi Blue

4B, gives a sky blue, Naphthogene Blue R a navy blue, Naphthogene Blue 4R a reddish blue, Zambesi Indigo Blue R a dark blue. (B. A. Co.). The Sulphine dyes are usually faster than the Oxamine dyes.

Choice of Dyes.

The question of dyeing is at first a very complex and difficult one for several reasons. Indigenous plant dyes are in some cases good, their use is well known to professional dyers and they can be obtained in the bazaars. But they are not easy to use, nor obtainable very pure ; when the services of professional dyers are obtainable, then the use of good vegetable dyes is sound. The range of colours is small, the colours are often dull and some of the best (*e.g.*, Annatto) are very fugitive to light. In every Indian bazaar are now to be found Anilin dyes, sold indiscriminately without regard to fastness to light or to water, used often carelessly and with curious methods and giving extremely crude colours that run into each other when woven side by side. Apparently Indian dyers and people generally have found bright colours to their hand, found them easy to apply so as to get results better than with their plant dyes and have used them to the exclusion of their natural dyes, often badly and crudely, producing very poor results. On the other hand, their intelligent use is not easy ; there are numerous firms selling these dyes, each firm giving fancy names to their own products, all competing and all selling fugitive as well as faster dyes. If the demand exists now, it has certainly been made and had these firms confined themselves to the better dyes, used a uniform nomenclature and put out their wares suited to a few processes easily mastered, then there might have been a possibility of the use only of the high class dyes on a proper system.

When one then gets into the complexity of acid, basic, neutral, direct, mordanted, developed, Alizarin and other dyes, one can understand how it is that the use of the most easily applied basic

(fugitive) dyes has become so general. We believe that the wisest course to recommend is :

(1) The use of either (*a*) good acid dyes fast to light ; (*b*) direct or substantive dyes or (*c*) Alizarin dyes, where one simple method is wanted, adhering throughout to one group, the acid dyes being the simplest but the least fast of the three groups.

(2) The use of indigenous dyes by professional dyers where such can be found.

(3) The use of only Alizarin dyes or of Alizarin dyes with acid dyes, where dyeing is done on any scale and the use of these dyes can be adopted.

If any industry in eri silk by firms, as apart from individuals, is being undertaken, we would recommend the use of the Alizarin dyes so far as possible but if not, then only of the best acid or direct dyes used intelligently. In this connection it is perhaps not unreasonable to suggest getting advice as to which dyes are fast and their manner of application, adhering to the products only of one firm and using their directions. There are firms producing dye-stuffs and selling them in this country who will give assistance to those who really want to use only fast and reliable dyes. We cannot advertise the wares of any firms ; we give below a list of some of the dye-stuffs sold in India which are, in our opinion, good for dyeing eri silk for all ordinary purposes, though they are inferior to the Alizarin colours. There are a host of tints and shades, of course, which cannot here be discriminated but advice as to obtaining particular colours is easily obtained.

RED.	*Direct Dye-stuffs.*	Thiazine Red G.
		Columbia Fast Scarlet 4B.
		Cotton Red 4B.
		Brilliant Congo R.G.
		Aceto purpurine. 8B.
	Diazotised.	Berolina Fast Red.
		Sulphine with Oxamine developer.
	Acid Dye-stuffs.	Azocardinal.
		Azo-Coccine 2R.
		Sorbine Red.
		Naphthol Red S,

ORANGE.	*Direct Dye-stuffs.*	Cotton Orange G. R.
		Pyramine Orange 3G.
		Congo Orange R. G.
		Mikado Orange.
YELLOW.	*Direct Dye-stuffs.*	Cotton Yellow R.
		Chrysamine G. R.
		Chrysophenine G.
		Curcumeine S.
		Columbia Yellow.
	Diazotised.	Sulphine with Soap.
	Acid Dye-stuff.	Azoflavine.
		Acid Yellow G. R.
		Azo-Acid Yellow.
		Curcumeine extra.
		Tartrazine.
		Flavazine (Acetic).
		Brilliant Yellow S.
		Fast Yellow extra.
		Fast Mordant Yellow G.
GREEN.	Get by combination of blue and yellow, *e.g.*, Tartrazine and Silk Blue.	
	Acid Dye-stuff.	Diamond Green.
BLUE.	*Direct Dye-stuffs.*	Chicago Blues, developed with bluestone.
	Diazotised.	Naphtogene Blue 6B.
	Acid Dye-stuff	Silk Blue B.
		Water Blue 6B.
		Induline N. N.
		Soluble Blue.
		Indocyanine B.
		Cyprus Blue R.
	Basic Dye-stuffs.	Alkali Blue with Borax (for light shades).
VIOLET.	*Direct Dye-stuffs.*	Columbia Violet R.
	Acid Dye-stuffs.	Acid Magenta S.
		Acid Violet 4R-7B.

The great number of Anilin Violets, especially the basic ones, are not fast to light; the shades are best got by combination of acid dyes, if Alizarin dyes cannot be used.

PINK.	*Direct Dye-stuff.*	Erica.	
	Acid Dye-stuffs.	Rhodazeine.	Mauve-pink, not fast to light.
		Rhodamine R.	
		Resoline G.	
BROWN.	*Direct Dye-stuffs.*	Thiazine Brown G. R.	
		Zambesi Brown G.	
	Mordant Dye-stuff.	Metachrome Brown.	
BLACK.	*Direct Dye-stuffs.*	Zambesi Black.	
		Oxamine Black.	
	Diazotised.	Zambesi Black.	
		Oxamine Black.	

	Acid Dye-stuffs.	Janus Black D. Black-Black. Balatine Black. Silk Black. Ethyl Black. Wool Black.
LILAC.	*Reduced Dye-stuff.*	Helindon Red.
SAGE GREEN.	Use Diamond Green and Mikado Orange or another Orange.	
MAROON.	*Scarlet.* *Brown.* *Violet.*	Combined to the right tint.

With a selection of the above dyes, and by judicious combination, almost any tint can be obtained. There are difficulties in getting such tints as green, brown, heliotrope, mauve, olive-green, unless one experiments with mixtures, either dyeing with a bath of two mixed acid dyes or by grounding with one dye-stuff and topping with another after. For securing deep shades the Alizarin dyes as grounding dyes followed by acid dyes are often useful. The fastness to light of two dyes together is not the same as that of each separately nor will the colour simply fade but will change, as one tint fades out faster than the other. This is true also of fastness to water ; thus one can get beautiful lilac shades with Erica and Silk Blue ; but on washing, the blue goes out, not the pink. One must therefore experiment. Dyeing is not a difficult matter if one restricts oneself to one class of dye-stuff ; it becomes a very technical and complicated business if one wants to dye with all dyes, or to dye mixed fibres (*e. g.*, cotton and silk), or to dye all classes of fabric (cotton, wool, silk, linen, etc.). But if the object is to produce simply dyed eri thread or cloth, there is no difficulty in the matter provided only one class of dye-stuff is used. Anyone can use the acid or the direct dye-stuffs ; good results can be got and with no special technical skill. The colours can be readily blended, or used in varying strengths and with the information supplied so readily by dye-stuff producers, there is no inherent difficulty. We have endeavoured to simplify the matter above and to recommend only fast dyes ; naturally good results will not be got by buying up any anilin dyes in the bazaars and using them, as is so often done, in very curious ways. But if one selects

the best, uses them according to the instructions given and exercises ordinary care, good results are easily obtained. Dyeing as practised by dyers who dye all classes of fabrics, who dye wool, cotton and silk separately or mixed, who print colours, who use "resists" and "discharges," and who must be able to turn out immense quantities of material to exactly even shades is, of course, a highly technical business; but to dye cocoons or yarn so as to get stripes or checks or coloured borders, or to dye in the piece, each piece separately or a few at a time is no difficult business and it is from that point of view we have discussed it above.

N. G. Mukerjee states that in the Rampur Boalia Sericultural School the dyes sold as Maypole Soap have been used in silk-dyeing, giving very showy results and very beautiful shades. These are mixture of dyes and salts, which dye direct in boiling water. The "Dolly Dyes" act in the same manner and a large range of colours are obtained very simply which, for dyeing on a small scale without regard to very great fastness to light, are quite satisfactory. These dyes are, in some cases, at least, substantive dyes with Glauber's salts and for dyeing on any but a very small scale are more expensive than purchasing the pure dye and requisite assistants.

We have been dyeing thread, cocoons and cloth constantly in Pusa, since we commenced weaving and we have now adopted one class of dye only, as being suited to our purposes and as being the best process for eri silk dyers who can use only ordinary appliances. We have abandoned the indigenous plant dyes, as the skill required to use them is very great and we have not employed a skilled dyer; (where there are such dyers, they should be employed). We have found Alizarin dyes very good but, with simple appliances, not satisfactory for more than a few shades; (they are suited only to dye-works and not to small dyers). We have abandoned diazotised dyes as being beyond the reach of the ordinary producer; and we have adopted a limited number of the acid and substantive dyes fast to light and to bleeding, all of which we treat with Tannin

and antimony after dyeing. The only addition is the mordanted dyes for khaki shades (single-bath method with Metachrome mordant or after mordanting with chrome), which may also be used for a limited range of shades of very great fastness, lac-dye for certain red shades and Alizarin with chrome or tin mordant for brick red or deep red.

The dyes used are the products of two firms sold in India ; enquiries were made from the trade through the Chamber of Commerce, Bombay, and we believe these dyes to be suitable to ordinary purposes. Unless very exceptional fastness is required (*e.g.*, dhoti borders) anyone wishing to produce dyed thread or fabrics will do well to use these dyes or similar substantive or direct dyes, of which there are other brands than those mentioned but which must be fast to light, fast to sizing and fast to bleeding into white silk.

The process of dyeing as we do it is simply as described above with Acetic Acid or Sulphuric Acid, with or without boiled-off-liquor, and with an after-treatment in Tannin and Tartar Emetic. The silk after dyeing is rinsed in water and put into three gallons of warm water containing one ounce of Tannin or two ounces of Tannin Extract or Myrabolans. After an hour it is well rinsed and turned in a bath of three gallons of cold water containing half an ounce of Tartar Emetic. It is then brightened in a weakly acid bath, washed and dried.

The following dyes require Sulphuric Acid :—

Azo-Coccine 2R.	Naphthol Red S. G.
	Sorbine Red G.
Azo-Cardinal G.	Palatine Scarlet A.
Cloth Red G.A.	Azocarmine.
Cloth Red 3 G. A.	Tartrazine.
Acid Yellow G.	Soluble Blue.
Azo-Acid Yellow.	Victoria Blue B.
	Silk Blue B.
Water Blue 3B.	Ethyl Black.

The following require Acetic Acid :—

Brilliant Congo R.	Thiazine Brown R.
Aceto-purpurine 8B.	Cotton Yellow G. I.
Columbia Fast Scarlet 4B.	,, Orange G. R.

Erica 2N.	Pyramine Orange 3G.
Salmon Red G.	,, Yellow G.
Mikado Orange 4R. O.	Cotton Brown R. V.
Chrysophenine G.	Oxamine Brown M. N. I.
Columbia Yellow.	,, Violet.
Curcumeine S.	,, Black.
Columbia Violet R.	Diamond Green G.

Any firm of dye-producers can match these dyes with identical or similar products of equal value: but it is not easy to get dyes which have a good fastness to light, sizing and bleeding, and which will dye silk; the enquirer who is not satisfied with the above should go in for wool-dyes fast to light acids, etc., or for Alizarins. For the producer of dyed fabrics on a small scale, wishing to use few chemicals and work on simple basis, we recommend the above dye-stuffs.

Columbia Fast Scarlet.	A warm bright crimson, light.
Azo-Coccine.	A bright crimson, with good depth. The nearest to scarlet.
Brilliant Congo R. G.	Dull crimson, tending to brick red.
Salmon Red G.	Clear dull red, tending to brick red.
Aceto-purpurine.	Bright red with a touch of mauve, less purple than fast red.
Cloth Red G. A.	Deep crimson with a touch of brown, no blue. Like lac on tin mordant.
Naphthol Red S. G.	Deep red with a touch of mauve like aceto-purpurine but redder.
Sorbine Red G.	Pure bright crimson.
Pyramine Orange 3G.	Orange tending to brown, no red.
Mikado Orange 4 R. O.	Deep orange red tending to salmon red.
Curcumeine S.	Yellow to orange, less brown than curcumeine extra.
Chrysophenine G.	Yellow to dull orange, no red.
Columbia Yellow.	Dull " old-gold " shade.
Azo-Acid Yellow.	Dull yellow, nearly " old-gold "; yellower and with more body than the last.
Acid Yellow G.	As the last.
Tartrazine.	Clear pure lemon-yellow, no orange.
Acid Yellow R.	Yellow orange, almost the same as pyramine orange 3G.
Cotton Yellow G. I.	Pale " old-gold " yellow, little body.
Thiazine Brown R.	An orange-brown, little red.
Oxamine Brown M. N. I.	A deep full umber-brown.
Indocyanine B.	Deep blue, dull, touch of indigo.
Soluble Blue T.	A very rich opal blue, bright.
Silk Blue.	Deep pure blue; in weak dyeings with boiled-off-liquor gives pale blue.
Water Blue 3 B.	A clear bright blue.
Ethyl Black 4 B. F.	A deep black tending to purple.
Columbia Violet R.	Purple-red, like lac on alum, dull.
Oxamine Violet R.	Deep rich purple, tending to blue.

V. THE CASTOR PLANT.

Castor Varieties.

All the varieties of castor we could obtain in India are eaten by eri silk-worms, and we have not been able to find any one variety better than another from their point of view. We have grown all the obtainable kinds of castor and have tried to pick those most productive of leaf. We have been unable to get any botanical classification of castors but this is in progress in South India. We rejected as unsuitable all the small leafed dwarf plants, such as the small *endi* of Surat; all the perennial varieties we obtained came down to six apparent varieties. The local Bihar varieties are all green or red stemmed with a white waxy covering on the stem and leaf-stalks; there are also brilliant green and red stemmed varieties with no wax; and we found in two lots (*Arend* of Cawnpore and *Thota Ahmedali* of Madras) a giant red or green variety with wax. We have, therefore, on mere appearance, habit and size separated out:

1. Green with wax.
2. Red .. ..
3. Green without wax.
4. Red .. ..
5. Giant green with wax.
6. ,, Red ,, ,,

The commonest varieties are both green and red with wax; amongst the plants collected at Pusa, the red and green without wax were found mixed, and are the best leaf-yielders of the varieties we have tested, but there is not a very marked difference and it would seem best to cultivate the local variety of perennial castor and not to attempt to introduce a special variety. We are testing the giant castor of Abyssinia, but until the varieties have been properly separated and the matter reduced to an accurate basis, any work with

castor varieties must be inaccurate. The question of leaf diseases of castor is also under investigation by the Imperial Mycologist; apparently the green stemmed variety without wax is liable to disease and so unsuitable.

It is essential to have the castor near the rearing house or the rearing house in the castor field and the usual method whereby a little castor is sown with other crops or on bunds, does not provide enough castor near at hand for rearing on a large scale, though it does so for cottage cultivation.

Also it is doubtful if growing pure castor is as profitable as growing castor with a ground crop such as sweet potatoes. With perennial castor one must sow wide apart, at least six feet between rows and plants; with closer sowings the plants run up and can scarcely be plucked at all. For leaf one wants a bushy plant, and it is useful to remove the leading shoot when the plants get four feet high.

It is absolutely essential for continuous rearing to have young leaf for the young worms; in Bihar a proportion of the plants should be cut down in February to provide young leaf in April-May to get the best results, one must bear this in mind and adopt the local practice of castor cultivation accordingly.

Yield.

Three-quarters of an acre of land yielded 45 maunds of leaf and eight maunds of seed. It was sown in April on irrigation, suffered heavily from caterpillar and was in the ground 9 months. Two acres yielded 160 maunds of leaf, 21 maunds 8 seers of seed and some more as a second crop. It was sown in October 1907, stood till January 1909, a total of 16 months.

Other Food Plants.

We have not found any other food-plant on which the insect can be properly reared; in Assam other food is used to keep the stock alive through the rains but this is not desirable, as seed is now obtainable so easily.

The Manure.

An acre of castor yields approximately 100 maunds of leaf of which about 30 maunds is turned into excrement and 30 maunds is waste leaf. The former when dried is a manure that should, according to the Imperial Agricultural Chemist, be applied at the rate of 4 maunds per acre. The latter is suitable as a green manure. In estimating the value of these as manure, the fact must be remembered that the excrement has been partly digested.

ERI SILK AS AN INDUSTRY

In a previous section we have discussed the climatic conditions under which eri silk can be grown and in considering the possibilities of eri silk cultivation in any locality one must first consider this. In Assam, eri silk is grown from October to March mainly; one reason why it is not grown in the rains is that castor does not thrive then, another is that the parasitic fly is active then. In Lower Bengal, eri silk can be grown at all times so far as the climate is concerned. In Bihar, the worms thrive and grow rapidly from June to November; there is then a slow winter brood and the following broods in March, April and May are liable to suffer from the extreme dry heat. In the United Provinces this is still more marked and it is better to cease rearing altogether for April and May, as the trouble of keeping the rearing houses moist is considerable. Good broods of cocoons have been obtained in the Punjab and Central India, but the long winter and longer period of dry heat make the cultivation unsatisfactory. In Kathiawar and Gujarat, broods are obtained throughout the year except when dry hot weather prevails but the climatic conditions are suitable for about 10 months, the winter being so mild that the broods then are but little prolonged. From reports received from rearers, the West Coast and Malabar are well suited to the rearing throughout the year and much of South India is well adapted to it. The Deccan is too hot and dry in March to May but good broods are got at other times and, with some care, throughout the year. In the Central Provinces, rearing has been done only in Chanda and Beetul, but there successfully, and a great part of the Province is suitable.

The next consideration is the supply of food; it is probable that the quality of the leaf is the important factor in disease, but we do not know enough as yet to say what quality of leaf is dele-

terious. Mr. C. M. Hutchinson has found by enquiry in Assam that the rearers regard leaf that has been grown quickly, say after pruning in warm moist weather, as unsuitable, perhaps because of its high moisture content. On the other hand, very old leaf is probably not suitable and one of the greatest difficulties seems to lie in regulating the leaf-supply. I am inclined to believe our outbreaks of disease were in part due to too heavy plucking followed by a production of new leaf which we used for feeding and we have undoubtedly not regulated our broods to our leaf-supply. So far as can be seen the art lies in maintaining sufficiently large broods to use the leaf regularly and to pluck all full-grown leaf before it gets old but not to have to strip all the leaf at any one time. That is, for one acre of castor, six regular broods of 30,000 worms is better than irregular broods with one big one. With only one lot of plant, one must of course start with a small brood when the plants are young, but if one grows perennial castor and one crop overlaps another by three months (July to October) one can have regular even broods. This question is so much a matter of local conditions that it must be considered for each place and it is essentially one to be taken into account. The final consideration is the organisation of the industry. In Assam, the industry is already organised ; there are centres for the disposal of cocoons, for buying seed, for selling yarn or cloth. Elsewhere there are not and in Tirhoot, for instance, hundreds of rearers have given up for want of a market for cocoons. There is a demand for cocoons in Calcutta and Bombay ; but some organisation must be formed to put the small grower in touch with it. At the outset that organisation must be created and the natural organisation is a Zemindar or landowner able to purchase and hold small lots of cocoons or cloth and sell in large lots or able to arrange for the purchase of cocoons at fairs or markets. The Silk Mills in Bombay, for instance, do not care to buy smaller lots than 300 or 500 lbs. The carriage to Calcutta of small lots of cocoons is too heavy. So also for cloth ; there is only a local market for small lots but other markets for large lots.

The industry is one that depends on the presence of a buyer of small lots and as things are now, there is an assured market for large lots of cocoons. We find that cocoons can be reared in large rearing houses at Rs. 25 per maund of 82 lbs., paying for all our labour at from two to four annas a day. Such cocoons are selling now at from Rs. 60 to Rs. 80 so that there would seem to be a good margin for the middleman: the small rearer doing the rearing in his own house will not pay for labour as a rule so that a return of Re. 1 per seer should induce him to go in for it. In Assam, the rates paid fluctuate from 12 annas to Re. 1 per seer, depending on the quality of the cocoons, the large white fetching most, the brown least. We have eliminated the brown cocoons and all the seed we send out gives white cocoons.

We are opposed to large rearing houses and believe that rearing in small lots by cultivators is the best, as is done in Assam. In Gujarat and in Tirhoot, it is found that an obstacle is the carelessness of the people themselves, insufficient feeding producing poor cocoons; this is not universal but there is a tendency to it and in some localities it may be so ineradicable as to kill the industry. During the last year, we have trained a number of men in rearing, etc. To all we point out that it is useless going in for the industry unless they can sell cocoons or cloth and we have people come to Pusa thinking that they have only to learn and then we will make them well-to-do. But it is necessary to begin at the other end and, before coming, to consider if, in the locality in which it is intended to start, there is any likelihood of getting a sufficient volume of cocoons to be saleable.

With regard to cloth, it is quite clear that it is more profitable to get cocoons spun and woven if a good quality of cloth can be made which will find a market. This means organisation; it means giving out the cocoons for spinning; it means getting back thread and getting it woven into good even cloth suitable for the market. That this can be done where the women will spin and there are weavers, has been proved and the cloth fetches high enough prices if of good

quality, to make the profits much greater. But it is useless embarking on this unless one has taken account of this first.

Eri silk is in demand for several reasons and the demand is so ill met that there are imitations on the market made of waste mulberry and of mercerised cotton. But the demand must be understood. We have not exhaustively investigated this point but we have had experience of disposing of cloth. In Calcutta, as in Madras, and some centres in North India, good closely-woven cream cloth is wanted for suits. In Surat, a cheap open woven cloth is sold for dhoties, wrappers, etc., and is worn by Jains and others indoors only. In Assam, a greater range of cloth is made and sold; there is probably scope for enterprise in special fabrics for the Indian and Anglo-Indian trade provided the qualities and special features of eri silk are taken into account. The material is, for instance, admirably suited to all fabrics requiring durability: the "khaki shirting" is probably the ideal material for shikar clothing, expeditions, etc.; the possibilities of eri silk hosiery are not yet tested; the special qualities of the cloths, made of millspun eri, have not been exploited, and it is only in the last year that this material has been made at all in India.

We believe that there is an immense field for guaranteed eri fabrics in India, and that the very special qualities of millspun eri will lead to an immense demand both in India and in Europe; but in every point, enterprise is required. We cannot here adequately discuss this: we have tried to make as great a range of fabrics as possible from eri, and to anyone who is enterprising enough to come to Pusa and see, we will gladly give all the information in our power. Our object here is to point out that one cannot rush blindly into such an industry without forethought, and that while eri silk growing is easy and profitable where the conditions are right, we do not recommend it as an universal profitable industry.

We are here unable to fully discuss the one point that distinguishes eri silk from all others, *i.e.*, that the fact that in no process is life taken and on that account the silk is not objected to by Jains

and others who will not wear mulberry silk, as in getting this latter the cocoons must be stifled. We are told that it is for this reason that eri silk is worn in certain ceremonies and it is probable that some part of the demand is due to this point alone. In that case it is necessary to exactly meet the demand by putting on the market the special fabric required for these purposes and also by retaining the characteristic features of eri silk cloth, so that there can be no doubt of it. The Assam traders have already got a bad name, as their goods are sometimes made partly of mercerised cotton and it will be fatal to any industry if this adulteration is practised. Indian silk fabrics are already largely discredited in India owing to the immense amount of mercerised cotton, rhea and artificial silk, etc., used in their preparation and it is a very great pity that this practice has become so general. It will be a very strong point in the eri silk industry in new places if every article is made only of pure eri silk and is guaranteed so to be. It is a comparatively simple matter to detect admixture of cotton but even without that, the bad qualities of the fabric in actual wear will soon discredit it. We would urge intending-producers to investigate the local trade, find what eri silk is required for, get samples and work to samples, guaranteeing every piece as pure eri and if necessary submitting it to test.

Given that the climate is suitable, that there is castor available, how does one set about starting eri silk? In the first place, one wants a small central rearing house to start and to show people: we have arrangements now for seed-supply as shown above and seed is readily obtained. One wants a few trays as models or one must use cloth or matting. The first brood being through, the moths yield seed which is available for distribution. The cocoons left are cleaned when dry and put by. As rearers produce cocoons from the distributed seed, they are bought and preferably paid for on the basis of clean cocoons, *i.e.*, one cleans the cocoons on the Coryton Machine and pays on the basis of the weight of clean cocoons, or one cleans a sample and pays for the raw cocoons on the sample. If one buys raw cocoons, one may be paying for dead moths, etc., in the cocoons and so lose heavily. Cleaning is essential and the trade

prefer clean cocoons as do the spinners. As the cocoons accumulate, they are packed tightly in 20-seer lots, as much compression being applied as is practicable ; we pack in gunny, making each parcel up to 20 seers, as this is the most economical package for goods transit. Some railways give concessions for cocoons, taking them at half rates by passenger train and this concession will doubtless be extended if required. The cocoons are then sent off and the producer is charged one per cent. brokerage by the Calcutta buyers.

If it is intended to spin, it is best to give out the spinning and not to attempt it by spinning in a factory with paid labour. This is an important point, and one of the chief benefits of the industry is that it provides light work for women in their own houses. We give out clean boiled cocoons and expect to get back all the weight, *i.e.*, if we give a seer we expect so much thread, so much waste and if uncleaned cocoons are given, so much refuse ; we then pay Rs. 3 to Rs. 5 per seer of thread according to its fineness. The rates, of course, will vary according to locality. The thread is examined and is sorted into qualities, some being finer, some coarser. It is then given to the weaver for weaving with orders as to the class of cloth. The important thing is to get the cloth woven with a proper reed, usually 20 to 22 dents to the inch for suitings, but varying according to the class of cloth. This point must be attended to or unsaleable coarse cloths will be made. The cloths are then taken in, weighed after washing and the weight checked allowing a little for waste. The ordinary sizes of cloth are 11 yards by 27 inches, 7 yards by 40 inches, 3½ yards by 54 inches, but where long warps are made, it is best to warp out to 70 yards and weave 36 to 40 inches wide. For specially good cloths, fine threads are used for the warp but they are doubled to form a very smooth thread ; the usual method of doubling is to double it by means of the *charka* or hand-wheel, but this is far more expensive than doubling many pairs of threads at once on a proper doubling machine.

We have already pointed out that no use has as yet been made of eri yarn spun in mills. We have used yarns of the following

counts, made in Bombay: 140/2, 160/2 and 280/2. These yarns are almost identical with mulberry yarns but the unbleached fabric has a peculiar tinge of "dust" colour, a shade like very pale tussur and quite indescribable, while they can be bleached to a good cream colour. The fabrics are very soft and silky, far more durable than mulberry silk and far more resistant to perspiration, dust, etc. But unless bleached, they are not white and this natural colour which does not wash out, must be made use of. It makes the cloths suited specially to chudders, shawls, cloaks, rugs, etc., which are to be worn in the open and which are not required to show dust. The very finest fabrics can be made and the yarns dye readily as ordinary spun silks do. The lower counts of yarn are specially suited for warp, using hand-spun eri in the weft, the resultant fabric in this case being, of course, pure eri and of very good quality.

As things are at present, the mills are dependent upon growers for their supplies, the supplies from Assam being of bad quality very often and not making good yarn on account of the admixture of brown cocoons. It is therefore possible for large producers to send their cocoons to the Bombay Mills and to purchase pure eri yarns at the market rates.

Eri Silk as an Industry in Assam.

No enquiry has been made as to the extent of the present eri silk industry. It is grown for local use in many districts in Assam and in Bogra, Rangpur, Jalpaiguri and Mymensingh in Eastern Bengal. The industry is a small or "home" one, the cultivators rearing in their houses sufficient worms to provide silk for their own spinning and weaving, to clothe themselves with the cloth produced. The surplus is purchased by the factories or by dealers, the former as thread for weaving, the latter for sale in Calcutta for export to Europe, principally to Switzerland.

In Assam, the chief rearing is done from October to February; castor grows best at this time, not growing well during the monsoon

months owing to the excessive rain ; the parasitic fly is also troublesome up to October and is not active during the cold weather. For the rest of the year, the worms are kept going in small quantity upon castor or upon its other food-plants, which are said to include ber (*Zizyphus jujuba*), *Jatropha curcas*, keseru (*Heteropanax fragrans*), papaiya (*Carica papaya*), Gulasiphal (*Plumeria alba*), Cassava (*Manihot* sp.), etc. Rearing is done in Assam in much the same way as described above ; the trays are usually hung from the roof to keep off ants ; the cocoons required for silk are often put in the sun for a few days to kill the contained pupa, though this is not necessary. Both pierced and unpierced cocoons are sold in the bazaar, and those who do not rear their own, purchase them. The cocoons are boiled in ashes and washed ; they are then cleaned, by splitting laterally, placed one over another on a stick and spun. About $1\frac{1}{4}$ seers of cleaned cocoons yield a seer of thread. As much as Rs. 10 per seer is paid for fine thread. The work of spinning and weaving is mainly done by women. Rearing is regarded as successful if 3,500 cocoons are obtained from 5,000 eggs, but usually 2,500 or 50 per cent. only are actually obtained. Ants, parasites, dirty or close rearing and disease lessen the number of worms that mature. Pierced cocoons sell at Rs. 30 to Rs. 60 per maund, unpierced cocoons at half that price.

For a piece of cloth, 3 yards by 54 inches, $1\frac{1}{2}$ seers of thread are required, the weaving costing Rs. 2, six days being required for the weaving, including warping. Handloom factories for the production of the cloth exist at Gauhati, but Muga and Mulberry silks are also woven, as well as silk and cotton. The following are the catalogue prices of pure Eri cloth :

1st class Eri cloth :

A.	3 yards × $1\frac{1}{2}$ yards.	Rs.	20—25.
B.	6—7 yards × 1-$1\frac{1}{2}$,,	,,	32—40.
1.	,, ,, ,, ,,	,,	26—30.
2.	,, ,, ,, ,,	,,	21—25.
3.	6—$6\frac{1}{2}$,, ,, ,,	,,	16—20.
4.	$5\frac{1}{2}$—6 ,, × $1\frac{1}{4}$—$1\frac{1}{2}$,,	,,	14—15.

1st class Eri washed :			
B.	6—$6\frac{1}{2}$ yards × 50—52 inches	Rs.	32—40.
1.	,, ,, ,, ,, ...	,,	26—30.
2.	,, ,, ,, ,, ...	,,	21—25.
3.	. ,, × 47—49	,,	17—20.
4.	5—$5\frac{1}{2}$,, × 45—46 ,, ...	,,	14—15.
2nd class Eri unwashed.			
A.	3—$3\frac{1}{4}$ yards × $1\frac{1}{2}$ yards	,,	14—17.
1.	,, ,, ,, ,, ...	..	11—13.
2.	,, ,, ,, ,, ...	..	9-8 to 10-8.
3.	,, ,, ,, ,, ...	..	8-0 to 9-0.
4.	,, ,, ,, ,, ...	..	7-0 to 7-8.
5.	$2\frac{1}{2}$ to $2\frac{3}{4}$ yards + $1\frac{1}{4}$ to $1\frac{1}{8}$ yards	,,	6-0 to 10-0.

For dyeing, a charge of Rs. 2 to Rs. 2-8 is made for the whole piece.

Sale of Seed in Assam.

In Assam, eggs, seed cocoons as well as worms for seeding purposes are sold in hâts or local fairs. Eggs are tied in small bundles in small pieces of cloth, and these small bundles containing about 500 to 2,000 eggs are sold for $\frac{1}{2}$ anna to $1\frac{1}{2}$ annas. Seed cocoons are sold at the rate of 2 or 3 cocoons for a pice. A fieldman purchased twenty-five bundles of eggs numbering about 20,000 for Re. 1-8 and eight seed cocoons for eight annas.

Estimates.

In new enterprises, detailed estimates of the capital required, the recurring cost and the returns are usually looked to as giving an idea of the profitable nature of the industry. We cannot, for very good reasons, give such estimates, as the conditions under which the industry is done, vary so much. If one grows castor specially for the worms, rears in Central rearing houses with hired labour, does all the cleaning, spinning, weaving with hired labour in a factory, one is doing the business in the least possible economical way, though on paper it should pay even to do this. If one organises rearing among a number of villages close together, where castor is grown as a mixed field crop, if one gives out the spinning to the women in their houses, the weaving to weavers in their homes, one is doing

the business on the most economical and sensible lines and it is in this way that we advocate it.

We cannot estimate the profit because we have not been able to carry it on as a business in either system. We do most of our work by the expensive system of hired labour in a rearing house, but we give out the spinning as far as possible. We believe that it will pay to give out rearing and buy cocoons, either on a co-operative mutual system or paying for them at say annas 12 for raw, Re. 1 for cleaned cocoons, per seer. When spinning can be done, it will be more profitable to give the cleaned boiled cocoons out for spinning.

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